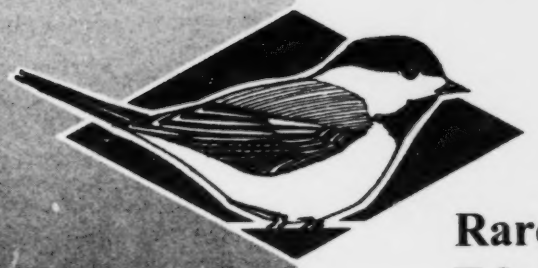

Fish & Wildlife Division

WILDLIFE CONSERVATION AND BIODIVERSITY SECTION

# Rare Plant Inventory of the Eastern Edge of the Lower Foothills Natural Subregion, West-Central Alberta

**Alberta Species at Risk Report No. 59**

Alberta
SUSTAINABLE RESOURCE DEVELOPMENT

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**Jennifer Doubt**

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**March 2002**

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SUSTAINABLE RESOURCE DEVELOPMENT

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## TABLE OF CONTENTS

**ACKNOWLEDGEMENTS**.....vii
**EXECUTIVE SUMMARY**.....viii
**1.0 INTRODUCTION**.....1
**2.0 DESCRIPTION OF THE WHITECOURT STUDY AREA**.....1
2.1 Climate.....2
2.2 Vegetation.....2
2.3 Physiography, geology, and soils.....3
**3.0 METHODS**.....4
3.1 Selection of locales and sites.....4
3.2 Site surveys.....5
**4.0 RESULTS AND DISCUSSION**.....6
4.1 Number and types of sites visited.....6
4.2 Rare non-vascular plants.....7
4.3 Rare vascular plants.....10
4.4 Descriptions of rare plants and occurrences.....11
*Aloina rigida*.....12
*Brachythecium rutabulum*.....13
*Dicranella heteromalla*.....15
*Dicranella subulata*.....17
*Hygrohypnum molle*.....18
*Hygrohypnum ochraceum*.....20
*Hypnum pallescens*.....21
*Hypocenomyce friesii*.....23
*Neckera pennata*.....24
*Physcomitrium hookeri*.....26
*Pogonatum dentatum*.....28
*Rhizomnium magnifolium*.....30
*Splachnum ampullaceum*.....32
**5.0 RECOMMENDATIONS**.....35
5.1 General recommendations for rare plant populations.....36
5.2 Recommendations for future surveys.....36
5.2.1 Logistical considerations of working with vascular and non-vascular plants.....36
5.2.2 Recommended target sites and locales in the Whitecourt study area.....37
**6.0 REFERENCES CITED**.....40
**7.0 APPENDICES**.....44
Appendix 1. Non-vascular plants and lichens recorded during the rare plant survey in the Whitecourt study area.....45
Appendix 2. Vascular plants recorded during the rare plant survey in the Whitecourt study area.....54
Appendix 3. Sites and regions of the Whitecourt study area that would benefit from further botanical exploration.....66
Addendum. Co-ordinates and descriptions of locales and sites visited for the lower foothills rare plant survey south-east of Whitecourt, Alberta.....69

## LIST OF FIGURES


Figure 1. Location and boundaries of the study area in which the rare plant survey was conducted. ....2
Figure 2. Locations of lower foothills study sites surveyed for rare vascular and non-vascular plants....7
Figure 3. Plants of *Aloina rigida*. ....12
Figure 4. Known Alberta distribution of *Aloina rigida*. ....12
Figure 5. Plants of *Brachythecium rutabulum*. ....13
Figure 6. Known Alberta distribution of *Brachythecium rutabulum*. ....14
Figure 7. Pine-dominated forest on Whitecourt Mountain Natural Area, where populations of the rare moss species *Brachythecium rutabulum, Dicranella heteromalla,* and *Pogonatum dentatum* were discovered. ....14
Figure 8. Plants of *Dicranella heteromalla*. ....15
Figure 9. Known Alberta distribution of *Dicranella heteromalla*. ....16
Figure 10. Plants of *Dicranella subulata*. ....17
Figure 11. Known Alberta distribution of *Dicranella subulata*. ....18
Figure 12. Plants of *Hygrohypnum molle* ....18
Figure 13. Known Alberta distribution of *Hygrohypnum molle* ....19
Figure 14. Plants of *Hygrohypnum ochraceum*. ....20
Figure 15. Known Alberta distribution of *Hygrohypnum ochraceum*. ....20
Figure 16. Plants of *Hypnum pallescens*. ....21
Figure 17. Known Alberta distribution of *Hypnum pallescens*. ....22
Figure 18. Birch forest in Whitecourt Mountain Natural Area, where populations of the moss species *Dicranella subulata* and *Hypnum pallescens*, and the lichen *Hypocenomyce friesii* were collected. ....22
Figure 19. Known Alberta distribution of *Hypocenomyce friesii*. ....23
Figure 20. Plants of *Neckera pennata*. ....25
Figure 21. Known Alberta distribution of *Neckera pennata*. ....25
Figure 22. Plants of *Physcomitrium hookeri*. ....26
Figure 23. In *Physcomitrium hookeri*, a row of cells around the mouth of the capsule peels readily away. ....27
Figure 24. Approximate Canadian distribution of *Physcomitrium hookeri*. ....27
Figure 25. Plants of *Pogonatum dentatum*. ....29
Figure 26. Known Alberta distribution of *Pogonatum dentatum*. ....29
Figure 27. *Pogonatum dentatum* growing interspersed with *Dicranella heteromalla* on the soil exposed among the roots of a fallen tree ....30
Figure 28. Plants of *Rhizomnium magnifolium*. ....31
Figure 29. Known Alberta distribution of *Rhizomnium magnifolium*. ....31
Figure 30. Plants of *Splachnum ampullaceum* ....32
Figure 31. Known Alberta distribution of *Splachnum ampullaceum*. ....33
Figure 32. Treed fen in which one of two populations of *Splachnum ampullaceum* was discovered. ....33

## LIST OF TABLES

Table 1. Landscape features sampled in the Whitecourt study area, and their relative representation in the sampling of vascular and non-vascular plants. .....6

Table 2. List of the rare non-vascular plant and lichen species documented in (and near, in the case of *Aloina rigida*) the Whitecourt study area. . .....8

Table 3. Summary of recommendations resulting from the rare plant survey.....35

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## EXECUTIVE SUMMARY

A rare plant inventory was conducted in the area delineated by Highways 16, 22, 43, and 32, south of Whitecourt, Alberta, to identify and locate rare vascular and non-vascular plant populations. The inventory was conducted in the summer (July – September) of 2001, and followed, where possible, Alberta Native Plant Council guidelines. The study discovered 14 populations representing 12 rare non-vascular plant species (*Aloina rigida, Brachythecium rutabulum, Dicranella heteromalla, Dicranella subulata, Hygrohypnum molle, Hygrohypnum ochraceum, Hypnum pallescens, Neckera pennata, Physcomitrium hookeri, Pogonatum dentatum, Rhizomnium magnifolium,* and *Splachnum ampullaceum)* and two populations of a rare lichen (*Hypocenomyce friesii*). No rare vascular plant populations were confirmed. Although a geographically and physiographically broad range of sites was sampled, most rare plant occurrences (nine non-vascular plant populations and one lichen population) were detected on Whitecourt Mountain. Eight rare species occurrences were protected in provincial natural areas (six in Whitecourt Mountain Natural Area). Rare plants were found in a variety of habitat types, characterized by varying levels of human influence. This study resulted in the identification of potential threats to the rare plant populations discovered and of measures that may enhance their protection. Suggestions for future surveys, both in terms of logistical considerations and of promising future sampling locations, were derived from experience gained in this project.

## 1.0 INTRODUCTION

Rare plants and their habitats have received little attention in the northern east slopes of Alberta. What few rare plant records exist appear to have been associated with pre-development surveys or to represent the incidental collections of interested botanists. The region supports many land uses (e.g. active agriculture, oil and gas development, and forestry) and faces increasing development pressure, making the identification and location of rare species increasingly urgent.

Rare plant surveys are a critical first step in locating, assessing and monitoring rare species. They are important to land use management for the protection of Alberta's biological diversity and for determining priorities for further research. This document summarizes a Department of Sustainable Resource Development Fish and Wildlife Management Division rare plant survey in Alberta's lower foothills.

The purposes of this study were:

1. to document the distribution and occurrence of rare plants and their habitats as a critical first step to ensuring that they are protected, and
2. to provide guidance for future survey work.

## 2.0 DESCRIPTION OF THE WHITECOURT STUDY AREA

The survey area (distinguished in this report as the 'Whitecourt study area') encompassed a 1600 $km^2$ region of west-central Alberta bounded in the east and west by Highways 22 and 32, respectively, and in the north and south by Highways 43 and 16, respectively (Figure 1) (Cornish 2001). The study area occurs at the eastern edge of the Lower Foothills Natural Subregion as described by Beckingham et al. (1996), and straddles the western boundary of the Dry Mixedwood Subregion in the east and the southern tip of the Central Mixedwood Subregion (Beckingham & Archibald 1996) in the north. The largest towns in the study area are Whitecourt and Mayerthorpe, which mark the northern corners of the study area, and several small settlements (including Carrot Creek, Green Court, Niton Junction, Nojack, Peers, and Wildwood) also fall within the survey boundaries. The area encompasses parts of 23 townships (Cornish 2001). The area includes both 'White Zone' (primarily in the east, managed by Alberta Agriculture, Food, and Rural Development) and 'Green Zone' (primarily in the west, managed by Alberta Sustainable Resource Development) lands.

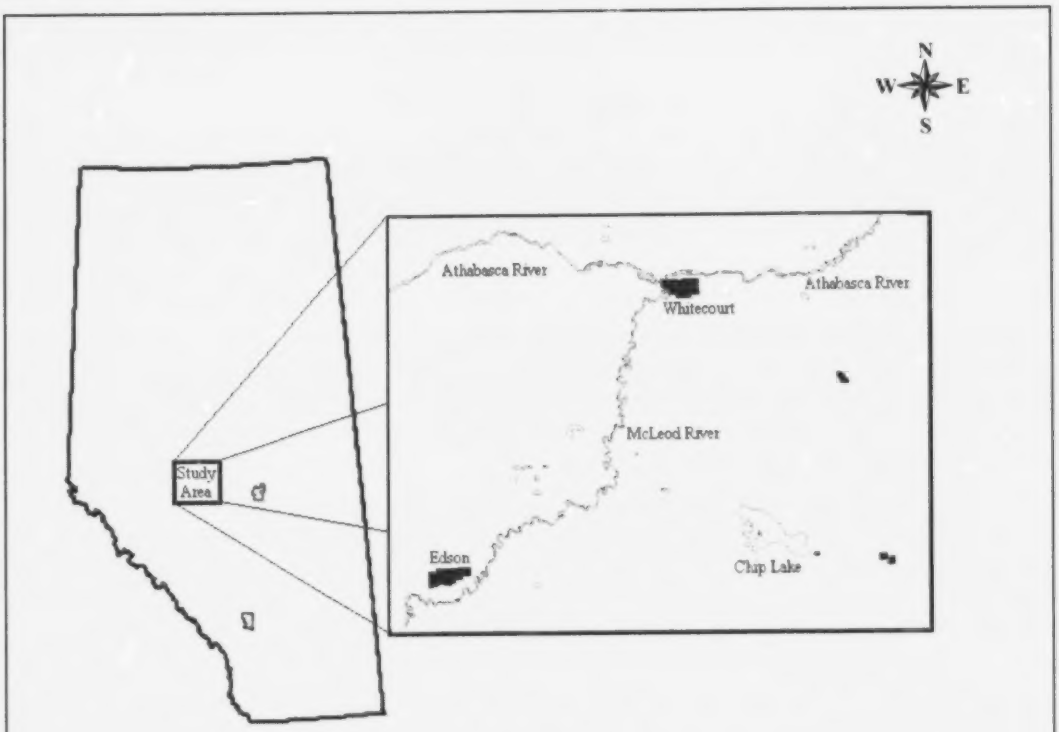


Figure 1. Location and boundaries of the study area in which the rare plant survey was conducted.

## 2.1 Climate

Beckingham et al. (1996) report mean summer temperatures in the Lower Foothills Natural Subregion of around 13°C and mean winter temperatures around –8°C. Annual precipitation averages 464 mm. Whitecourt averages 65 frost-free days in a growing season (Wynnyk et al. 1969). While Beckingham et al. (1996) characterize the climate of the Lower Foothills as cooler in the summer and warmer in the winter than the adjacent Boreal Forest subregions, the Whitecourt study area, which straddles both subregions, features a less moderate climate than Foothills regions further west. Topographic and physiographic variability in combination with the transitional position of the study area probably also lead to wide climatic variability within the relatively small study area, creating a diverse array of plant habitats.

## 2.2 Vegetation

Forests of the Lower Foothills Natural Subregion are dominated by aspen (*Populus tremuloides*), balsam poplar (*Populus balsamifera*), lodgepole pine (*Pinus contorta*), and white spruce (*Picea glauca*) (Beckingham et al. 1996). Mature white spruce and lodgepole pine stands are less common in the study area than mixedwood and aspen communities (personal observation). The incidence of coniferous trees increases toward the west in the study area, while aspen overstories become more common toward the east (personal observation). Wetlands account for up to 25% of the study area

(Twardy & Lindsay 1971), and are characterized by black spruce (*Picea engelmannii*) and tamarack (*Larix laricina*), as well as a proliferation of mosses. Plant communities in the study area are described and/or classified by several authors, including Beckingham et al. (1996), Downing (1999), Environmental Management Associates (1993), and Lesko and Lindsay (1973).

A large number of anthropogenic and successional habitats are also characteristic of the study area: agricultural activity concentrated in the east part of the study area has created large tracts of cultivated and grazed land; forestry has led to the occurrence of cut blocks in the west; oil exploration and extraction has resulted in ubiquitous transitional 'edges' between natural forest and artificial clearings. The region is periodically affected by fire, creating more successional variability.

## 2.3 Physiography, geology, and soils

The largely low, level to rolling topography of the landscape ranges in elevation from about 720 m, where the Paddle River exits the study area to the east, to approximately 1125 m at Whitecourt mountain in the north-west corner of the study area. Highlands to about 900 m also occur north and north-west of Chip Lake. The area is dissected by watercourses, with the McLeod River and its 50 m deep valley running near and parallel to the western boundary, and the smaller Paddle and Lobstick Rivers running from east to west across the north and south parts of the study area, respectively. Meanders and oxbows characterize many rivers and creeks in the area, creating a wealth of bank habitats. Twardy and Lindsay (1971) report that flow in local drainage courses varies broadly throughout the growing season. Chip Lake is the largest lake, and many small lakes and ponds dot the landscape, particularly in the southern half of the study area.

Two bedrock formations underlie the study area. The Paskapoo formation (of Paleocene age) occupies most of the study area, while the Edmonton formation (of late Cretaceous aga) underlies a northern strip, 3-10 km wide (Twardy & Lindsay 1971, Wynnyk et al. 1969). Both of these formations are composed of standstones and shales, with a greater salt content characterizing the Edmonton formation and lime carbonate represented in significant amounts in the Paskapoo. Glaciation and post-glacial weathering have resulted in the surficial deposits that contribute to soil formation in the area. The distribution of surficial deposits, the majority of which are Paskapoo till, is detailed in Twardy and Lindsay (1971) and in Wynnyk et al. (1969).

Most soils in the study area are classified as "orthic gray wooded luvisols". They are described by Wynnyk et al. (1969) as moderately to imperfectly drained, having been developed under forest communities under moderate to cool climates from basic parent materials. Other soil types occur in the study area, most notably along the McLeod River and near the margins of the study area. These are discussed in depth by Wynnyk et al. (1969).

## 3.0 METHODS

### 3.1 Selection of locales and sites

Field work was conducted in the summer (July-September) of 2001 by one vascular plant specialist and one non-vascular plant (bryophyte) specialist, who also collected some lichens. 'Sites' were defined as landscape features (e.g. forests, peatlands, stream beds) such as those listed in Cornish (2001). Where possible, search boundaries within sites corresponded to the natural boundaries of each landscape feature. If the area described in this way was unmanageably large, a smaller, representative area was sampled. The presence of political boundaries such as property lines also affected site size on occasion. Several sites could be sampled at a given 'locale' if a number of interesting, accessible landscape features occurred in close proximity (walking distance).

An initial list of target locales and sites was made with reference to air photos and topographic maps, and this list was amended with the accumulation of sampling hours and field experience. Criteria outlined in Cornish (2001), logistical considerations, and the experience of the plant specialists led to the application of the following guidelines in selecting locales and sites for sampling:

1. Priority landscape features: A number of priority landscape features and their projected relative importance were proposed in the survey protocol (Cornish 2001). These guidelines, along with the field experience of the specialists who conducted the survey led to the general landscape feature classification and sampling emphasis used in the current survey (Table 1). In this classification, *grasslands and meadows* included graminoid-dominated habitats with less than 10% tree cover. *Deciduous and coniferous forests* had canopies composed of 90% or more deciduous or coniferous trees, respectively; all other forests were considered *mixedwood*. *Aquatic features and banks* included water bodies and water courses and the associated shoreline and bed / bank habitats. *Peatlands and marshes* featured some standing water (or species that indicated that high moisture was the normal condition at the site) but could still be navigated by foot. Anthropogenic habitats were of many types, including structures, road-cuts, ditches, and clearings. Some of these habitats overlapped with the other landscape features used in this study (e.g. cut-line through a peatland), but sites were considered anthropogenic if their presence was attributable solely to human activity.

2. Representative and unique landscape features: Landscape features representing all general types present in the study area were included in the sampling scheme. Unique and unusual landscape features were given special attention.

3. Rare species ecology: Cornish (2001) provided a list of rare species known to occur and likely to occur within the study area. The ecological preferences of these species were taken into consideration when selecting sites.

4. Geographic location: An effort was made to ensure that all geographical sectors of the study area were represented.

5. Human disturbance and protection: Both relatively natural areas and sites influenced by varying degrees of human activity were sampled in this study. Care was taken to include isolated pockets of natural habitat surrounded by agricultural or other development. Landscape features created by human disturbance ("anthropogenic" habitats such as road cuts) were also sampled. Provincial Natural Areas within the study were visited, as suggested by Cornish (2001).

6. Accessibility: Sites were generally close to roads or trails. Land ownership, both for prospective sites and for access routes, were taken under consideration, and most sites represented publicly-owned land.

## 3.2 Site surveys

Specialists conducted field work for a total of 18 person-days (10 days for vascular plants and eight days for non-vascular plants). Each site (each landscape feature of interest at each locale) was carefully examined in a systematic fashion, according to Alberta Native Plant Council (2000) guidelines. All plants at each site were identified to a level at which their provincial rarity, as defined by the Alberta Natural Heritage Information Centre (ANHIC 2001), could be determined, or were collected for laboratory examination. ANHIC rankings take each species' provincial distribution and abundance into account, based on guidelines developed by The Nature Conservancy (ANHIC 2001).

Care was taken to survey the full range of microhabitat conditions present at each site, with special attention devoted to localized conditions known to support the rare species listed by Cornish (2001). The location and general conditions of each site (e.g. vegetation type, apparent moisture regime, land uses, etc.) were recorded, but rigorous site descriptions and population assessments were not undertaken in the absence of confirmed rare species occurrence. Most bryophyte specimens could not be determined in the field, and were identified later, from collections. When a rare species was confirmed in the field, photographs were taken and notes on the extent of the occurrence were made.

Bryophyte identifications were made with reference to Lawton (1971) for most moss species and to Schuster (1977) for the liverworts. Additional reference to Crum (1984), Crum and Anderson (1981), Koponen (1974), Nyholm (1954), and Peterson (1979) was required for some species. Scientific nomenclature for mosses was standardized to North American checklists (Anderson 1990, Anderson et al. 1990), and common names of rare mosses were referenced in Glime (1989, 1991, 1992, 1993, 1994a,b) and Glime and Zhang (1990). Moss (1983) constituted the primary reference for vascular plants. Lichen specimens were sent away for taxonomic evaluation (J.D. Johnson, Edmonton, Alberta). Lichen nomenclature followed Esslinger (1997), and key taxonomic resources for lichens included Bird (1970), Goffinet & Hastings (1994),

Goward (1999), Goward et al. (1994), and Thomson (1984, 1997). All occurrences of rare species discovered in association with this report were submitted to ANHIC.

Table 1. Landscape features sampled in the Whitecourt study area, and their relative representation in the sampling of vascular and non-vascular plants.

| **Landscape feature type** | | **Number of examples visited** | | | |
|---|---|---|---|---|---|
| | | Non-vascular plants | | Vascular plants | |
| Grasslands & Meadows: | | 2 | | 2 | |
| Forests | (Deciduous) | 33 | (13) | 31 | (8) |
| | (Coniferous) | | (8) | | (7) |
| | (Mixedwood) | | (12) | | (16) |
| Aquatic Features & Banks | (Rivers & Streams) | 16 | (12) | 8 | (4) |
| | (Ponds & Lakes) | | (4) | | (4) |
| Peatlands & Marshes | | 20 | | 15 | |
| Anthropogenic | | 7 | | 1 | |
| **TOTAL SITES VISITED** | | **78** | | **57** | |

## 4.0 RESULTS AND DISCUSSION

### 4.1 Number and types of sites visited

Ninety-eight sites (representing 47 locales) were examined for this survey. Fifty-seven sites (representing 31 locales) were surveyed for rare vascular plants, and 78 sites (representing 36 locales) were surveyed for rare non-vascular plants (Table 1). As suggested by Cornish (2001), the greatest emphasis was placed on forested and wetland sites. However, because vascular and non-vascular plant diversity and rarity will not necessarily co-occur (eg. Dirkse & Martakis 1998, Pharo et al. 1999) priority landscape features differed slightly between the two plant groups. To maximize the chances of detecting rare vascular and non-vascular plants, landscape feature priorities deviated somewhat from the suggested protocol (Cornish 2001), and different degrees of emphasis were placed on different landscape features for each plant type. Aquatic habitats and the banks of water courses received more attention than recommended by Cornish (2001) due to the potential for discovering rare bryophyte species such as *Physcomitrium hookeri*, and *Dicranella* spp. A relatively greater proportion (54%) of sites sampled for rare vascular plants was forested, compared with the proportion of forested sites sampled for rare non-vascular plants (42%). Conversely, a greater proportion of anthropogenic landscape features (8%) was sampled for rare non-vascular plants as compared with rare vascular plants (2%).

The spread of sites on the map of the study area (Figure 2) shows that a geographically representative sample of the study area was examined.

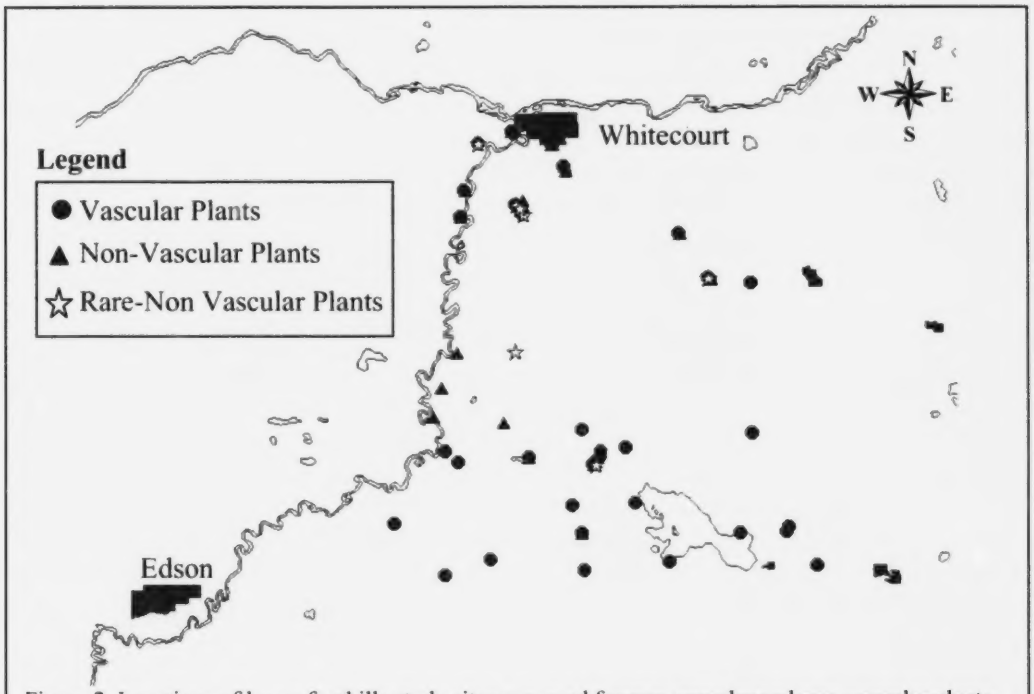


Figure 2. Locations of lower foothills study sites surveyed for rare vascular and non-vascular plants. Stars indicate sites where rare plants were documented.

## 4.2 Rare non-vascular plants

About 400 non-vascular plant specimens were collected; however, it was not possible to identify all of these specimens within the budget allotted for this project. Examination of the most promising specimens collected showed the presence of eleven non-vascular plant species (13 occurrences) tracked by the Alberta Natural Heritage Information Centre (ANHIC 2001) in six different locales within the study area (Table 2). An eleventh rare non-vascular plant species – *Aloina rigida* – was recorded during an incidental visit to Pembina River Provincial Park, just outside the south-east boundary of the study area. One rare lichen species was also detected at two of the sites and locales inhabited by rare non-vascular plants. The number of rare non-vascular plants known from the study area has increased from two to twelve species as a result of this study.

Rare species were not evenly distributed through the study area. Rare species in this study were largely found in the north part of the study area, but sites from the south were also represented (Figure 2, Table 2). Nine of the rare species occurrences documented in this study were clustered in two locales on Whitecourt Mountain. The ten Whitecourt Mountain rare species occurrences were distributed among just four of the fifteen sites sampled there; in two instance, three rare species occurred in a single site. No more than one rare species was found at each of the other six locales within the study area where rare species were detected. Whitecourt Mountain may therefore represent a

significant reservoir of rare species within the study area. The patchy distribution of rare species distribution in this study reflects patterns observed by other researchers (e.g. Vitt & Belland 1997).

Table 2. List of the rare non-vascular plant and one lichen species (*) documented in (and near, in the case of *Aloina rigida*) the Whitecourt study area.

| **Rare species** | **Alberta rank** | **Landscape feature type(s)** | **General locale(s)** |
|---|---|---|---|
| *Aloina rigida* | S2 | Anthropogenic | Pembina River Provincial Park |
| *Brachythecium rutabulum* | S2? | Coniferous Forest | Whitecourt Mountain Nat. Area |
| *Dicranella heteromalla* | S1 | Coniferous Forest | Whitecourt Mountain Nat. Area |
| *Dicranella subulata* | S2S3 | Anthropogenic | Whitecourt Mountain Nat. Area |
| *Hygrohypnum molle* | S1 | Stream | Whitecourt Mountain |
| *Hygrohypnum ochraceum* | S2 | Stream | Whitecourt Mountain |
| *Hypnum pallescens* | S1 | Deciduous Forest | Whitecourt Mountain Nat. Area |
| *Hypocenomyce friesii** | S2 | Deciduous Forest, Mixedwood Forest | Whitecourt Mtn. N.A.; Whitecourt |
| *Neckera pennata* | S1 | Deciduous Forest | West-central region of study-area |
| *Physcomitrium hookeri* | S1 | Stream Bank | Beta Lake Natural Area |
| *Pogonatum dentatum* | S2S3 | Coniferous Forest, Anthropogenic | Whitecourt Mtn. N.A. (2 populations) |
| *Rhizomnium magnifolium* | S2 | Stream Bank | Whitecourt Mountain |
| *Splachnum ampullaceum* | S2 | Peatlands | Whitecourt; 13 km W of Mayerthorpe |

Most of the rare species occurrences were recorded in forests (eight occurrences, Table 2), which may reflect and substantiate the emphasis placed on forests during site selection. Peatlands, conversely, yielded only two occurrences of rare species despite the strong emphasis placed on these habitats. The examination of aquatic features and water margins resulted in the discovery of three rare plants (two sites), including the most rare species (*P. hookeri*) found in this survey. Anthropogenic habitats were home to three rare bryophyte species in this study. These results show that streams and anthropogenic habitats should not be overlooked in surveys for rare non-vascular plants.

Of the 16 rare species occurrences recorded, three were on anthropogenic sites and almost all of the sites housing rare species were influenced by human activity (such as wood harvesting, clearing, and grazing). Three of the eight locales shown to house rare species were protected as parks and natural areas, while only seven (two parts of Beta Lake Natural Area, two parts of Whitecourt Natural Area, Whitecourt Mountain Natural Area, Balm Natural Area, Nojack Recreation Area) of the 47 locales visited were protected. This may give evidence of the importance protective conservation measures to rare species. Some degree of human disturbance was evident in most sites regardless of protection, however, and the degree to which human activity maintained or inhibited rare species health was difficult to determine.

The occurrence of four of the rare species (*Brachythecium rutabulum*, *Hypocenomyce friesii*, *Pogonatum dentatum*, *Splachnum ampullaceum*) discovered in the study area was projected by Cornish (2001) based on previous recordings of their occurrence in or near the study area. Cornish (2001) predicted the occurrence of 19 other moss species and six more lichens within the study area, which were not detected in the current investigation. Further study in the Whitecourt study area may yet reveal the presence of these species. The majority of the rare species discovered (9) were not anticipated by previous authors. This shows that while lists of predicted species can be useful in the preparation stages of a rare plant survey, researchers should caution against bias introduced by a plant 'hit-list'.

Several of the rare species discovered in this survey (e.g. *Hygrohypnum ochraceum*, *Neckera pennata*) are common in nearby provinces or states. Their occurrences in the Whitecourt study area help to delimit the species' range limits and to clarify their national distribution. Other rare species (e.g. *Brachythecium rutabulum, Hypnum pallescens, Rhizomnium magnifolium, Splachnum ampullaceum*) may soon be removed from or demoted in rank on Alberta tracking lists as botanical exploration proliferates and taxonomic concepts improve (for further details, see section 4.4), and the current study aids our understanding of the species' rarity. The most significant find, *Physcomitrium hookeri*, constitutes one of very few known national populations. It is known only from Alberta and Manitoba, and one of the two previously-recorded Alberta populations was last observed in Calgary in 1908.

In addition to rare species occurrence records, the survey adds records for each of at least 84 non-rare bryophyte species and 18 lichens to the study area (Appendix 1). Some of these occurrences (e.g. *Atrichum selwynii, Brachythecium turgidum*) are significant for reasons other than rarity in that they represent the species' eastern range limits in Alberta, as they are most commonly associated with Rocky Mountain habitats. The transitional location of the Whitecourt study area between the foothills (itself a transition from mountain to plains) and boreal mixedwood natural subregions probably accounts for the presence of species at their range limits, and makes it especially interesting for plant surveys.

## 4.3 Rare vascular plants

No rare vascular plants were detected in this study. Thorough searches of sites where rare species were previously recorded and of a widespread diversity of habitat types, however, contributed records for 143 non-rare vascular plant species to knowledge of the study area (Appendix 2). One occurrence of *Potamogeton natans* (ranked S2 in Alberta) along the north-east margin of Chip Lake (Appendix 2,3) could not be confirmed because deep water prevented thorough observation of all plant parts. It is recommended that this site be re-visited.

Two main factors probably contributed to the absence of rare vascular plant discoveries in this study. Firstly, rare species may have occurred at sampled sites, but may not have been at a stage of development conducive to locating or positively identifying them when the sites were sampled. Most sites were visited only once during the single growing season, biasing the search in favour of species that were mature at the time of sampling. To some extent this problem was mitigated by re-visiting landscape feature types (represented by different sites) over the July-August period. For logistical reasons, no spring sampling was possible. The Alberta Native Plant Council (ANPC 2000) recommends, conversely, that specialists survey a study area at least twice during the growing season, and states that more visits are preferable. Furthermore, the ANPC (2000) suggests that a study area be assessed over a number of growing seasons to account for fluctuations in climate and other outside factors that may affect plant germination, growth, and flowering. Time constraints and the size of the study area prevented these recommendations from being followed in the current study. Bryophyte sampling is much less dependent on seasonal timing than vascular plant sampling, so that most species can generally be detected and identified at any time during the snow-free season. The detection of rare bryophyte species therefore does not suffer as much as the detection of rare vascular plants when it is not possible to re-visit sampling sites.

Secondly, rare vascular plants species are more thoroughly collected and understood in Alberta than rare non-vascular plants. As a result, the rarity of many non-vascular plants may be mis-represented in ANHIC rankings and may be dropped from tracking lists as collection records accumulate. Vascular plants, on the other hand, are much more likely to be as rare as ANHIC rankings suggest. Until there has been as much exploration for non-vascular plants as there has been for vascular plants, it is expected that ANHIC-tracked vascular plants will be much less frequently encountered than ANHIC-tracked bryophytes.

## 4.4 Descriptions of rare plants and occurrences

In this section the rare bryophyte species discovered through this survey are discussed in detail. The level of detail included depends on the amount of information available and the apparent significance of the species' occurrence. The format employed is shown below:

***Scientific name***
**Common name(s)** **Provincial Rank**

| | |
|---|---|
| Location | Geographic location of the population(s) |
| Habitat | Habitat(s) and substrate(s) where the population(s) were discovered |
| Recommendations | Actions required to document, assess, and/or protect the population(s) |

Description: A brief description of the species' physical appearance is given. In most cases, this description is accompanied by a photograph of a specimen of the species collected for this report.

Distribution: The Alberta distribution of each species, as reported by the Alberta Natural Heritage Information Centre (ANHIC), is described and a map showing these previously known locations is provided. The locations of populations discovered in the current survey are described and mapped. The significance of newly-recorded populations from the Whitecourt study area is highlighted. The global or North American distribution of each species is given for context.

Habitat: The habitat and substrates supporting each rare plant population are described.

Population: When it was noted at the time of collection, the extent and condition of each rare species population is described.

Threats / Recommendations: Potential threats to the populations of each rare species discovered in the Whitecourt study area are outlined. Actions that would improve the documentation, assessment, and/or protection of the rare plant population(s) are discussed.

Specimen(s): Collection numbers for voucher specimens and the herbarium in which they will be accessioned are provided.

***Aloina rigida***
**Aloe-like rigid screw moss** **S2**

Location .....Pembina River Provincial Park
Habitat.....On roadside railway bridge support
Recommendations.....Avoid publicizing species' occurrence
Avoid human disturbance of species' substrate
Monitor population

Description: *Aloina rigida* is a minute moss species (up to 3 mm tall) producing rosettes of fleshy leaves reminiscent of those of the common house plant *Aloe* (Figure 3). Its slender capsules are borne on setae (stalks) that may reach 17 mm long (Crum & Anderson 1981), which help draw attention to the otherwise inconspicuous plants in the field.

Figure 3. Plants of *Aloina rigida* resemble minute *Aloe* plants. (Jennifer Doubt)

Distribution: Thirteen Alberta populations of *Aloina rigida* are known, including the current record (Figure 4). They are relatively widespread, occurring from the mountains (Kootenay Plains, Jasper National Park) east to Medicine Hat. G.R. Pegg collected *A. rigida* from a Whitecourt area road cut in 1964 (ANHIC 2001), but details on the location were not sufficient to search for the population in the current study. Several populations were previously known from the Edmonton area, and the current record represents a new point connecting mountain and foothills populations with those of the Edmonton region. Furthermore, no record for *A. rigida* has been made since 1980 (ANHIC 2001), so the current record is important in confirming the persistence of *A. rigida* in Alberta.

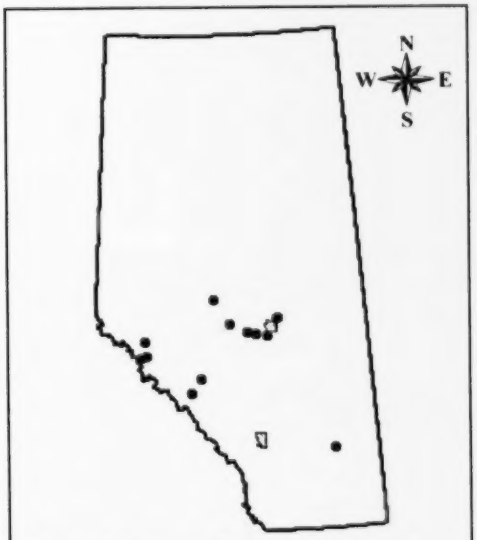


Figure 4. Known Alberta distribution of *Aloina rigida*.

*Aloina rigida* is described as "rare and scattered" throughout its North American range, which includes populations centred in the east and west parts of the continent (Crum & Anderson 1981, Delgadillo 1975).

Habitat: *Aloina rigida* is known to prefer fine, calcareous silt (Crum & Anderson 1981), and in Alberta has been collected largely from road cuts and the banks of creeks or rivers (ANHIC 2001). The current collection was made from a concrete human construction in Pembina River Provincial Park. The occurrence of *A. rigida* so close to the study area may be attributable to the presence of this rare occurrence of calcareous 'rock'.

Population: The Pembina River population of *A. rigida* is quite small (<5 $cm^2$), but appeared healthy and was producing copious capsules.

Threats / Recommendations: As this population inhabits a historical structure in a provincial park, its habitat is relatively secure, but disturbance by visitors or personnel maintaining the structures could threaten the population. For these reasons it may be prudent not to publicize or draw attention to the population and to avoid cleaning moss from the structure.

Specimen: J. Doubt #7444 (March 9, 2001), Devonian Botanic Garden.

***Brachythecium rutabulum***
**Rough-stalked feather moss, Large grass moss** **S2?**

Location .....Whitecourt Mountain Natural Area
Habitat.....Mature forest with little human disturbance, dominated by lodgepole pine (*Pinus contorta*), on coniferous debris at the base of a fallen tree
Recommendations.....Maintain habitat character and diversity in Whitecourt Mountain Natural Area
Re-visit population to complete assessment

Description: *Brachythecium rutabulum* is a robust (leaves 2-3 mm long), shiny moss species with a creeping growth form (Figure 5). It is variable and may be difficult to separate from other *Brachythecium* species (Crum & Anderson 1981).

Figure 5. Plants of *Brachythecium rutabulum*. (Jennifer Doubt)

Distribution: *B. rutabulum* has been reported from twenty widespread Alberta sites (Figure 6), including Jasper, Fort McMurray, Edmonton, High River, Waterton Lakes, and Cypress Hills. Because the genus *Brachythecium* is

taxonomically difficult, collectors tend to avoid it in the field and specimens are often mis-identified, leading to inaccurate concepts of species rarity and distribution (hence the question mark in the species' provincial rank). Cursory inspection of the Alberta records for *B. rutabulum* suggests that some reports of the species may be incorrect.

*B. rutabulum* is common in eastern North America and in Europe, and is known in Africa, Asia, Hawaii, and New Zealand (Crum & Anderson 1981). In Canada it becomes increasingly less common west of Ontario.

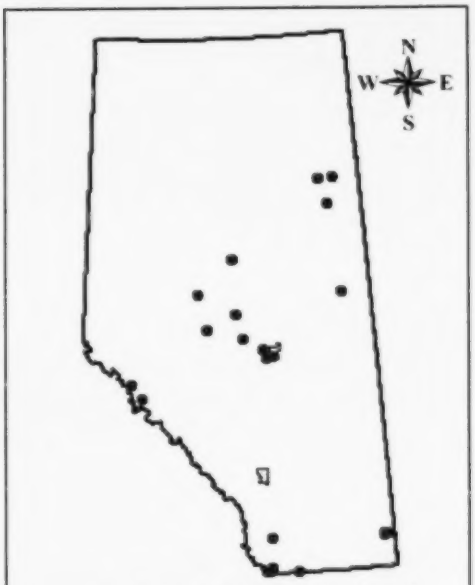

Figure 6. Known Alberta distribution of *Brachythecium rutabulum*.

Habitat: *B. rutabulum* was collected from dry coniferous debris at the base of a fallen pine tree in an apparently dry, open coniferous forest (Figure 7). Several common bryophyte species at the site, including *Polytrichum commune,* however, seemed to indicate moisture. Crum and Anderson (1981) report that the species prefers "soil or humus, rocks, decaying logs, and bark at the base of trees in wet forest habitats". Other Alberta occurrences have been reported from many habitat types, including dry or mesic forests, wet sedge meadows, peat bogs, open prairie, and dry cliffs. Again, verification of these specimens may lead to a new interpretation.

Population: The extent of the Whitecourt Mountain population was not assessed, as the rarity of the specimen was not recognized at the time of collection. A few stalks of old capsules were seen, giving evidence that the population is capable of reproduction. Two other rare species (*Dicranella heteromalla* and *Pogonatum dentatum*) in this study were found at the same site, in close proximity (within a metre) to *B. rutabulum*.

Figure 7. Pine-dominated forest on Whitecourt mountain, from which *Brachythecium rutabulum*, *Dicranella heteromalla*, and *Pogonatum dentatum* were collected. (Steve Bradbury)

Threats / Recommendations: The Whitecourt Mountain site for *Brachythecium rutabulum* showed no signs of recent human disturbance. The protection of the Whitecourt

Mountain Natural Area by controlling human disturbance and maintaining the character and diversity of existing habitats will help to preserve *Brachythecium rutabulum* there.

Specimen: J. Doubt #7625A (June 28, 2001), Devonian Botanic Garden

***Dicranella heteromalla***
**Silky fork moss, Green hair moss, Variable small-curved tail moss** **S2**

Location .....Whitecourt Mountain Natural Area
Habitat.....Mature forest with little human distrubance, dominated by lodgepole pine (*Pinus contorta*), on sand exposed by fallen tree.
Recommendations.....Maintain habitat character and diversity in Whitecourt Mountain Natural Area
Re-visit population to complete assessment
Re-visit sites, including roadsides on Whitecourt Mountain, where immature *Dicranella* species were observed

Description: *Dicranella heteromalla* is a small (approximately 1 cm tall), shiny, tufted moss with slender, lance-shaped leaves (Figure 8). Like most members of the genus, it is difficult to identify in the absence of mature sporophytes (fruiting bodies), which have a distinctive appearance (Crum & Anderson 1981), including a yellowish seta (stalk). This species may therefore be represented in other, sterile (and therefore unidentifiable) collections from the study area. Revisiting the sites where these collections were made is recommended (Appendix 3).

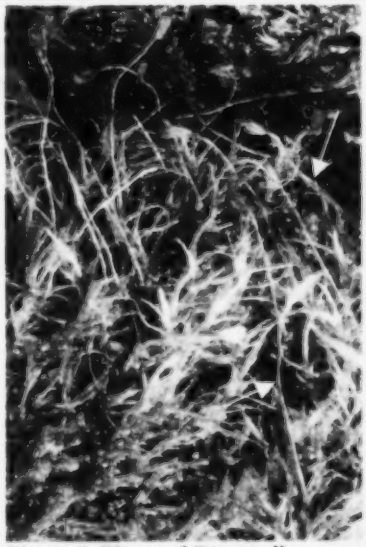

Figure 8. Plants of *Dicranella heteromalla*. The yellow setae (indicated by arrows) help to distinguish this species. (Jennifer Doubt)

Distribution: In Alberta, just three populations of *D. heteromalla* were previously recorded: In the Crowsnest Pass, Swan Hills (E.H. Moss, 1961), and west of Whitecourt on the Little Smoky River (C.D. Bird 1961) (Figure 9). The 2001 discovery of *D. heteromalla* confirms the persistence of the species in the Whitecourt area.

Globally, *D. heteromalla* is found in Europe, Japan, South America, and throughout eastern North America (Crum & Anderson 1981). It also occurs less frequently on the west coast of North America from Alaska to California.

Habitat: Crum and Anderson (1981) describe the preferred habitat of *D. heteromalla* as the soil of "shaded banks, especially along woodland trails, or on soil covering upturned roots of trees". In the current study the population was found on

the soil clinging to the roots of a fallen tree in a dry or mesic lodgepole pine (*Pinus contorta*) forest (Figure 7). Further information appears in the discussion of *Pogonatum dentatum*.

Population: The extent of the Whitecourt Mountain population was not assessed, as the rarity of the specimen was not recognized at the time of collection; a second visit to the site is required. *D. heteromalla* was observed to be fruiting abundantly at the site. Two other rare species (*Brachythecium rutabulum* and *Pogonatum dentatum*) in this study were found at the same site, within a metre of *D. heteromalla*.

Threats / Recommendations: The site showed no signs of recent human disturbance, and its protection within the Whitecourt Mountain Natural Area will help to preserve *Dicranella heteromalla*. Because the Whitecourt Mountain population(s) may rely on freshly-exposed soil, successional changes may affect the species' persistence. Maintenance of the character and diversity of habitats in the Natural Area may therefore aid the persistence of *D. heteromalla* there. The maintenance of mature forests on sandy sites, where natural windfall is a regular occurrence, will supply *D. heteromalla* with fresh substrates as older substrates become less hospitable. Monitoring of the entire pine forest habitat in addition to the individual population is therefore important.

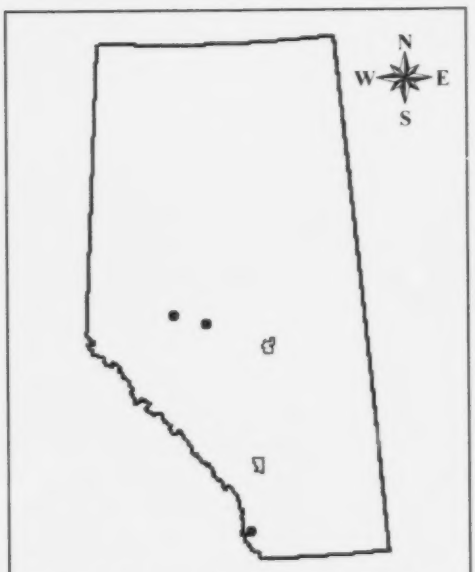

Figure 9. Known Alberta distribution of *Dicranella heteromalla*.

Soil disturbance along the road up Whitecourt Mountain was found to support populations of *Pogonatum dentatum*, with which *D. heteromalla* was intermixed at the pine forest site. *D. heteromalla* was not detected on roadside soil in the current study, although immature specimens of *Dicranella* were collected, and efforts to discover additional populations along the sandy road cuts near the top of Whitecourt Mountain are recommended.

Specimen: J. Doubt #7625B (June 28, 2001), Devonian Botanic Garden

***Dicranella subulata***

**Awl-leaved fork moss, Inclined small-curved-tail moss, Claw earth moss** **S2S3**

Location .....Whitecourt Mountain Natural Area
Habitat.....In wetland clearing associated with a communications tower, on fine-textured mud
Recommendations.....Examine nearby habitats of similar character
Re-visit population to complete assessment
Monitor habitat and population
Re-visit sites where immature *Dicranella* species were observed

Description: Small (3-10mm tall) plants of the moss *Dicranella subulata* grow in yellowish tufts (Figure 10) (Crum & Anderson 1981). The leaves are subulate, meaning that they have relatively broad bases but that the upper majority of each leaf is abruptly and dramatically narrowed. Like most members of the genus, it is difficult to identify in the absence of mature capsules, which have a distinctive appearance, including a reddish seta (stalk) (Crum & Anderson 1981). This species may therefore be represented in other, sterile (and therefore unidentifiable), collections from elsewhere in the study area. Revisiting the sites where these collections were made is recommended (Appendix 3).

Figure 10. Plants of *Dicranella subulata*. Reddish setae (indicated by arrows) help to distinguish this species. (Jennifer Doubt)

Distribution: Fourteen locations for *D. subulata* are known for Alberta (Figure 11). Most of these are in the mountains, in the Jasper and Kananaskis areas, although less recently-recorded populations are known from scattered locations further east, including Swan Hills and Whitecourt (collections by G.R. Pegg from 1964 and 1968, respectively (ANHIC files)). According to Crum and Anderson (1981), *D. subulata* is found in northern and central Europe, Japan, and eastern and western North America.

Habitat: *D. subulata* prefers soil banks, often in rocky places (Crum & Anderson 1981). The Whitecourt Mountain population of *D. subulata* was on very flat, fine-textured mud in a graminoid-dominated clearing associated with a communications tower. Alberta collections of *D. subulata* represent a range of anthropogenic (e.g. road- and trail-sides) and natural (e.g. coniferous forests, stream banks) habitats, including one collection from a wet meadow, such as the 'man-made' meadow on Whitecourt Mountain.

Population: The extent of the Whitecourt Mountain population of *D. subulata* was not assessed, as the rarity of the specimen was not recognized at the time of collection. Abundant capsules were noted.

Threats / Recommendations: Disturbance by forest clearing for the installation and maintenance of a communications tower appears to have created an environment conducive to the growth of *D. subulata*, and changes in human activity (either an increase or a decrease) at the site may alter the favourability of the habitat. Further investigation of similar habitats on Whitecourt Mountain is recommended, both to document the extent of the population and to assess potential threats to its persistence.

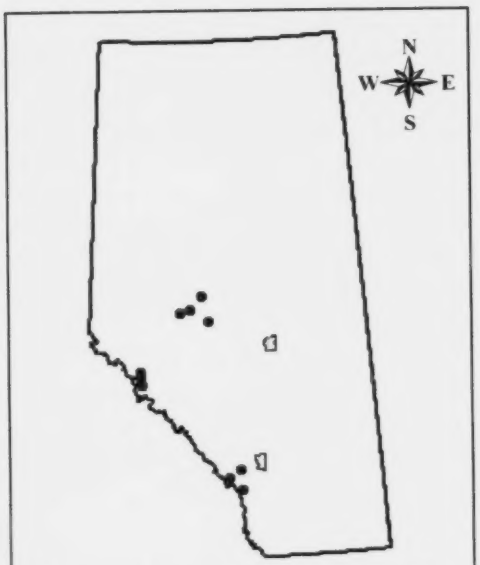

Figure 11. Known Alberta distribution of *Dicranella subulata*.

Specimen: J. Doubt #7603 (June 28, 2001), Devonian Botanic Garden

***Hygrohypnum molle***
**Round-leaved Hypnum, Soft-leaf wet-gray moss, Soft brook moss** **S1**

Location .....Whitecourt Mountain
Habitat.....Small rock- and gravel-bottomed stream through Aspen (*Populus tremuloides*) forest, on wet rocks and logs
Recommendations.....Examine stream upstream and downstream of population to complete assessment of extent and vulnerability
Monitor habitat and population

Description: *Hygrohypnum molle* is a small to robust moss, forming stiff mats 2 – 8 cm deep. The leaves (0.8-2.0 mm long) are spreading and quite round (Figure 12), distinguishing them from most other species of *Hygrohypnum*.

Distribution: Seven other occurrences of *H. molle* are recorded by ANHIC (2001) (Figure 13), but these are concentrated in just two

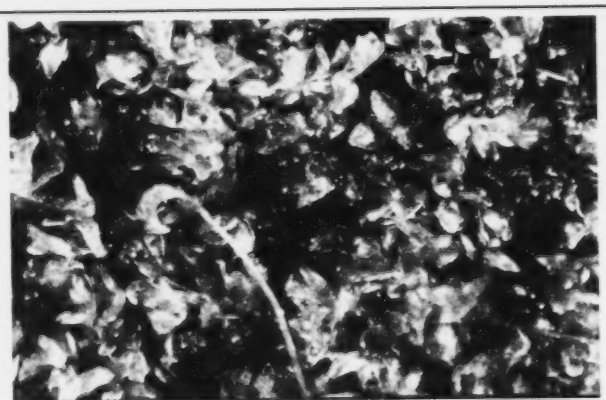
Figure 12. Plants of *Hygrohypnum molle*. This species forms stiff mats and has rounded, erect leaves. (Jennifer Doubt)

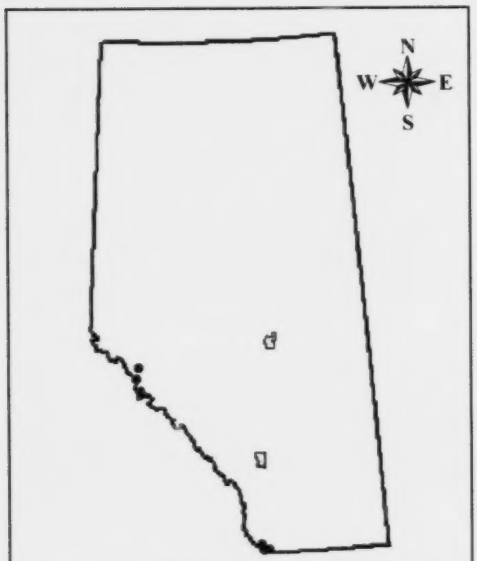


Figure 13. Known Alberta distribution of *Hygrohypnum molle*.

general locations. *H. molle* is known from three Jasper sites and four sites in Waterton Lakes National Park. The Whitecourt Mountain population, therefore, is significant in that it represents the only western Canada population east of the Rockies, and represents the eastern-most occurrence of *H. molle* in Alberta.

*Hygrohypnum molle* is known from eastern and western North America, but it is most common in the east. In the west, it is distributed from south-east Alaska to California and inland to Colorado, Montana, Arizona, and the Northwest Territories. Alberta represents the eastern limit of the western population in Canada. It is also known, globally, from Siberia and central Asia (Crum & Anderson 1981).

Habitat: *Hygrohypnum molle* grows on wet rocks in flowing water or splashed by spray. The Whitecourt Mountain stream in which *H. molle* occurs flows over rocks and fallen wood, through a moist aspen (*Populus tremuloides*) stand.

Population: As the species was identified in the laboratory, its rarity was unknown at the time of collection. The abundance of *H. molle* at the site was not noted. The collection made on Whitecourt Mountain bears fruiting structures. Two other rare species, *Hygrohypnum ochraceum* and *Rhizomnium magnifolium*, were found at the same site.

Threats / Recommendations: The site occurs just west of the Whitecourt Mountain Natural Area, and as such is not officially protected. The section of stream on which *H. molle* was discovered is downstream from a cut-line that appears to be used by recreational vehicles. Monitoring of the habitat and the population is recommended. Furthermore, a thorough search upstream and downstream from the original site to assess the extent of the species' occurrence, to seek occurrences within Natural Area boundaries, and to locate other rare species should be conducted.

Specimens: J. Doubt #7661 (June 28, 2001), Devonian Botanic Garden

***Hygrohypnum ochraceum***

**Yellow mountain-rill moss, Pale yellow wet moss, Claw brook moss** **S2**

Location .....Whitecourt Mountain

Habitat.....Small rock- and gravel-bottomed stream through Aspen (*Populus tremuloides*) forest, on wet rocks and logs

Recommendations.....Examine stream upstream and downstream of population to complete assessment of extent and vulnerability

Monitor habitat and population

Description: *Hygrohypnum ochraceum* is a medium-sized (leaves 1.4-3.6 mm long), creeping moss species with variably falcate (hooked) leaves (Figure 14). It is distinguished from other *Hygrohypnum* species largely by microscopic features.

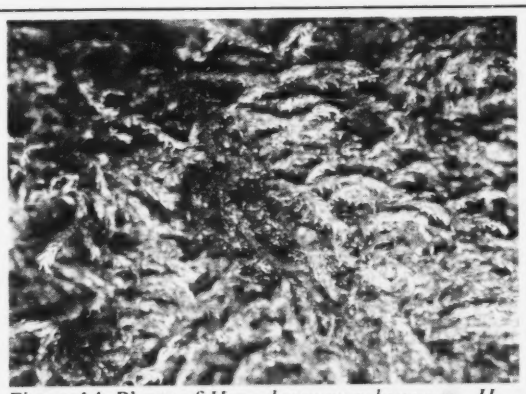

Figure 14. Plants of *Hygrohypnum ochraceum*. *H. ochraceum* has hooked leaves and is assocated with running water. (Jennifer Doubt)

Distribution: Nine other occurrences of *H. ochraceum* are recorded by ANHIC (2001) (Figure 15). Two of these are in Jasper, and the remaining seven are in Waterton Lakes National Park. The Whitecourt Mountain population, therefore, is significant in that it represents the only western Canada population east of the Rockies, and represents the eastern-most occurrence of *H. ochraceum* in Alberta.

*Hygrohypnum ochraceum* is known from eastern and western North America, but it is most common in the east. In the west, it is distributed from Alaska to California and inland to Colorado, Montana, Alberta, and the Northwest Territories. Alberta represents the eastern limit of the western population in Canada. It is known, globally, from Greenland, Europe, and Asia.

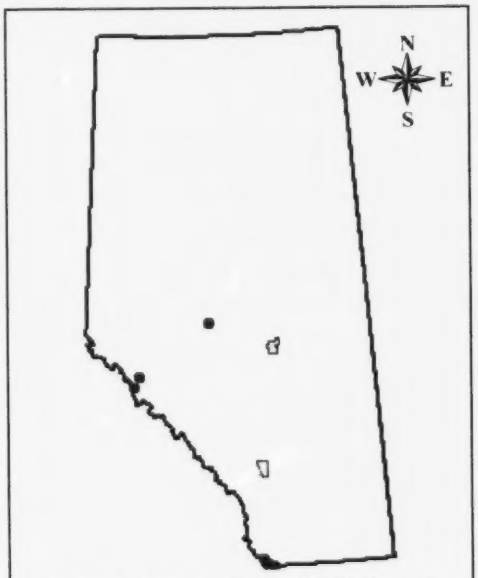


Figure 15. Known Alberta distribution of *Hygrohypnum ochraceum*.

Habitat: *Hygrohypnum ochraceum* dwells on rocks associated with flowing water, either submerged or splashed by the spray. The Whitecourt Mountain stream in which *H. ochraceum* occurs flows over rocks and fallen wood, through a moist aspen (*Populus tremuloides*) stand. Crum

and Anderson (1981) describe *H. ochraceum* as an acidophile. As most rocky habitats in Alberta are calcareous, the species' preferred growing conditions are not common in the province; further exploration of the Whitecourt Mountain site may reveal more rare plants.

Population: The species was plentiful at the Whitecourt Mountain site, with at least five colonies exceeding 100 $cm^2$ occurring on rocks and logs near the water level. No fruiting structures were seen. Two other rare species, *Hygrohypnum molle* and *Rhizomnium magnifolium*, were found at the same site.

Threats / Recommendations: The site occurs just west of the Whitecourt Mountain Natural Area, and as such is not officially protected. The section of stream on which *H. ochraceum* was discovered is downstream from a cut-line that appears to be used by recreational vehicles. Monitoring of the habitat and the population is recommended. Furthermore, thorough searches upstream and downstream from the original site to assess the extent of the species' occurrence, to seek occurrences within Natural Area boundaries, and to locate other rare species that may rely on the locally uncommon stream chemistry are needed.

Specimens: J. Doubt #7651, 7652, 7658 (June 28, 2001), Devonian Botanic Garden

***Hypnum pallescens***
**Small epiphytic creeping moss, Yellow gray moss, Stump pigtail** **S1**

Location .....Whitecourt Mountain Natural Area
Habitat.....Tree bases and stumps in birch (*Betula papyrifera*) forest
Recommendations.....Re-visit population to complete assessment
Monitor habitat and population
Be vigilant for *H. pallescens* in similar Alberta habitats

Description: *Hypnum pallescens* grows in fine-textured dark green, yellowish-green, or brownish-green mats (Figure 16). Leaves measure only 0.6-1mm in length, which is smaller than most other Alberta species of *Hypnum*. A pinnate branching pattern and serrate leaf margins also help to distinguish it.

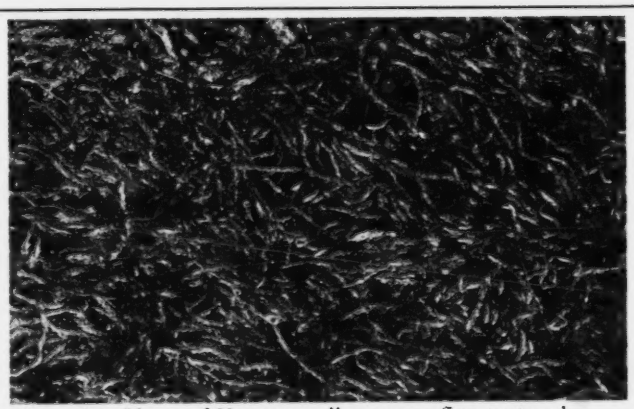

Figure 16. Plants of *Hypnum pallescens* - a fine-textured, creeping moss. (Jennifer Doubt)

Distribution: Five Alberta localities for *H. pallescens* are listed by ANHIC (2001): Grande Cache, Jasper, Bow Valley Provincial Park, Waterton Lakes, and Fort

McMurray (Figure 17). Two more central-Alberta specimens are housed at the Northern Forestry Centre in Edmonton, and the species is abundant at the Devonian Botanic Garden, near Edmonton (personal observation). These latter records and the Whitecourt Mountain population add an eastern dimension to the Alberta distribution of the species, which was originally thought to cover only the western part of the province. Undercollection may have falsely underestimated the species' abundance in Alberta.

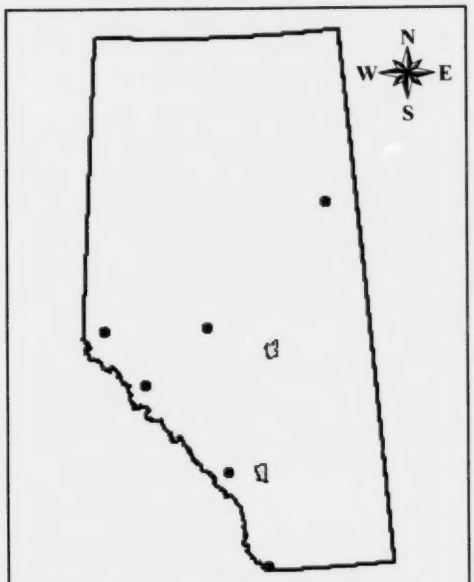

Figure 17. Known Alberta distribution of *Hypnum pallescens*.

*H. pallescens* is common in eastern and far-western North America, but is apparently more rare in the prairie provinces (Crum & Anderson 1981, ANHIC 2001). Globally, *H. pallescens* is widespread in Europe and is reported from Siberia, Kashmir, eastern Asia and Japan (Crum & Anderson 1981).

Habitat: *H. pallescens* was collected from tree bases and stumps in a birch forest (Figure 18) near the top of Whitecourt Mountain. Crum and Anderson (1981) report that *H. pallescens* occurs on bark at the bases of coniferous and deciduous trees, and on calcareous and noncalcareous rocks in dry and moist woods. Alberta collections represent both tree base and rocky substrates (ANHIC files). The extent of available habitat in Alberta for this apparently adaptable species supports the suggestion (above) that the species may occur more commonly than current records suggest, particularly in wooded habitats that are traditionally thought to be bryologically uninteresting (and are therefore undercollected).

Figure 18. Birch forest in Whitecourt Mountain Natural Area, from which the moss *Hypnum pallescens* and the lichen *Hypocenomyce friesii* were collected. (Jennifer Doubt)

Population: Although the rarity of the species was not recognized at the time of collection, three large collections of the species were made from different stumps and tree bases, indicating that *H. pallescens* was relatively abundant at the Whitecourt Mountain site. A few mature capsules were observed on one collection.

Threats / Recommendations: The forest in which *H. pallescens* was found bordered a wet, graminoid-dominated, clearing associated with a communications tower, and some evidence of human activity (prayer flags, fresh stumps, slash, abandoned supplies) existed, particularly at the margin of the clearing. However, the presence of nearby substrates and habitats similar to that in which the species was found and the protection afforded by the Natural Area designation suggest that the population is secure. It is recommended that the site be re-visited to complete the assessment of the population and that the population be monitored regularly in view of its proximity to human disturbance. Future collectors should be vigilant for *H. pallescens*, especially in deciduous forest habitats that traditionally receive little bryological attention.

Specimens: J. Doubt # 7604, 7611, 7616 (June 28, 2001), Devonian Botanic Garden

***Hypocenomyce friesii***
**Clam lichen** **S2**

| | |
|---|---|
| Locations | Whitecourt Mountain Natural Area |
| | Whitecourt Forest Interpretive Centre |
| Habitat | On charred wood of stumps in birch and pine forests |
| Recommendations | Re-visit sites to assess populations (lichenologist required) |
| | Monitor populations |
| | Collect and identify lichens on charred wood in Alberta |

Description: *Hypocenomyce friesii* is a crustose lichen consisting of greenish, overlapping, shingle-like squamules and blackish apothecia (Brodo et al. 2001). The flattened squamules of *H. friesii* make it less conspicuous in the field than the more raised, whitish squamules of *H. scalaris*, a similar but common species, and this may have led to under-collection.

Distribution: ANHIC possesses seven widespread Alberta records for *H. friesii* (Figure 19). One of these populations fell within the Whitecourt study area, (Nojack Recreation Area) but was not re-discovered in 2001. In North America, *H. friesii* is thought to possess a similar distribution (Derek Johnson, personal communication) to *H. scalaris*, which ranges across all territories and provinces and into the southern United States in the east and west (Brodo et al. 2001).

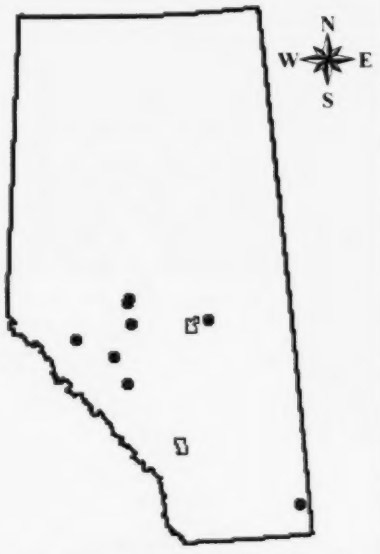

Figure 19. Known Alberta distribution of *Hypocenomyce friesii*.

Habitat: According to Brodo et al. (2001), members of the genus *Hypocenomyce* prefer the wood or bark of conifers or birch trees, especially charred logs or stumps. All Alberta specimens of *H. friesii*, including those discovered in the current study, were collected from charred wood. Derek Johnson (personal communication) points out that the species' preferred substrate is very common in Alberta and that, therefore, increased collection of specimens and records may prove it to be less rare than current records suggest.

Population: Although the populations were not assessed in detail because the species' rarity was not known at the time of collection, *H. friesii* was abundant on each charred stump on which it was found in this study. Charred wood was common at these sites. A rare non-vascular plant species, *Hypnum pallescens*, was also at the Whitecourt Mountain site.

Threats / Recommendations: Although the Whitecourt Mountain site is protected within the Whitecourt Mountain Natural Area, the forest in which *H. friesii* was found showed evidence of human activity (prayer flags, fresh stumps, slash, abandoned supplies). The population at the Whitecourt Forest Interpretive Centre appears not to be protected, but the interpretive value of forest stands next to the Centre may discourage habitat destruction. Both populations should be re-visited by a lichenologist to complete population assessments and to examine potential human threats, and ongoing monitoring is recommended.

Specimens: J. Doubt # 7589 (June 27, 2001), 7608 (June 28, 2001), Devonian Botanic Garden

***Neckera pennata***

| **Feathered neckera, Feather flat moss, Aspen feather moss** | **S1** |
|---|---|
| Location | South east of Whitecourt |
| Habitat | Mature deciduous woodlot with white spruce (*Picea glauca*) understory and recently cut wood stacked between the trees; on furrowed bark of balsam poplar (*Populus balsamifera*). |
| Recommendations | Seek further occurrences of *N. pennata* at the same site<br>Monitor population<br>Watch for *N. pennata* in moist deciduous stands |

Description: *Neckera pennata* is a large (leaves 2 – 2.5 mm long), distinctive moss with shiny, complanate (flat and 2-ranked), undulate (transversely wavy) leaves (Figure 20). It may be confused in Alberta with the much more common *Metaneckera menziesii* without microscopic examination. The latter has a well-defined single costa (leaf midrib) whereas *N. pennata* has no costa, or one that is short and doubled.

Distribution: In Alberta, five recent localities are listed by ANHIC (2001) for *N. pennata* (Figure 21). Four of them are north and/or east of Fort McMurray, but one population is listed from Jasper National Park. The population discovered in this study, therefore, is significant in that it was previously unknown from the Whitecourt region and in that it narrows a distributional gap. *Neckera pennata* occurs throughout North America but is rare in the prairie provinces.

Figure 20. Plants of *Neckera pennata*. This species has distinct spreading, complanate (flattened), undulate leaves. (Jennifer Doubt)

Habitat: The specimen of *N. pennata* collected for this survey was growing in a managed aspen (mostly *Populus tremuloides*) stand, on the deeply-furrowed bark of a mature balsam poplar (*Populus balsamifera*), about 1.5 m above the forest floor. Moss species on the forest floor (e.g. *Aulacomnium palustre, Plagiomnium ellipticum*) indicated high moisture. None of the previous populations of *N. pennata* in Alberta are known to have been collected from poplar trunks, although detailed notes are few. Nonetheless, tree trunks and bases are the most common substrate for *Neckera pennata* in regions where it commonly occurs. It is also often found on vertical rock, logs, and stumps (Crum & Anderson 1981). It is generally found in forest habitats and seems to prefer diffuse rather than direct light. Deciduous forest habitats in Alberta are thought to be very uninteresting in terms of non-vascular plants, and it is possible that other populations of *N. pennata* have been overlooked for this reason. Collectors are advised to watch for the species.

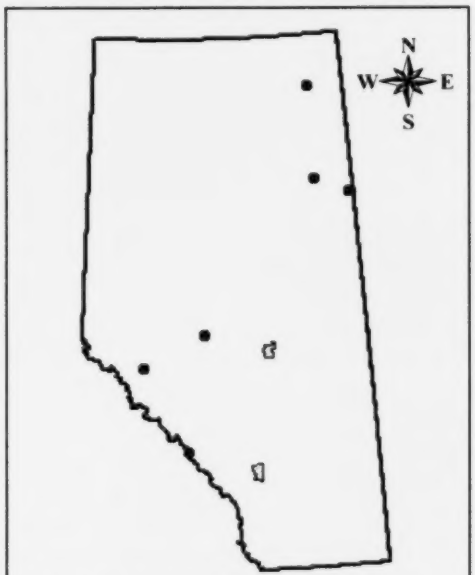


Figure 21. Known Alberta distribution of *Neckera pennata*.

Population: Very little material was found during the current survey, despite efforts to search as many mature trees as possible. Almost one half of the total observed population (3 $cm^2$) was taken to determine the species' identity. No fruiting bodies were seen.

Threats / Recommendations: Woodlot management practices may affect the survival of the species on the site, and monitoring and thorough site and population assessments are recommended. The discovery of additional occurrences of *N. pennata* within the site, if they are present, is particularly important.

Specimen: J. Doubt #7786 (August 1, 2001), Devonian Botanic Garden

***Physcomitrium hookeri***
**Hooker's bladder-cap, Hooker's bowl moss, Hooker's hood moss** **S1, N1**

Location .....Beta Lake Natural Area
Habitat.....Steep, muddy banks of meandering stream
Recommendations.....Re-visit population to complete detailed assessment
Search for new populations in nearby similar habitats
Monitor population and nearby habitat
Investigate upstream habitats and potential impacts of upstream development

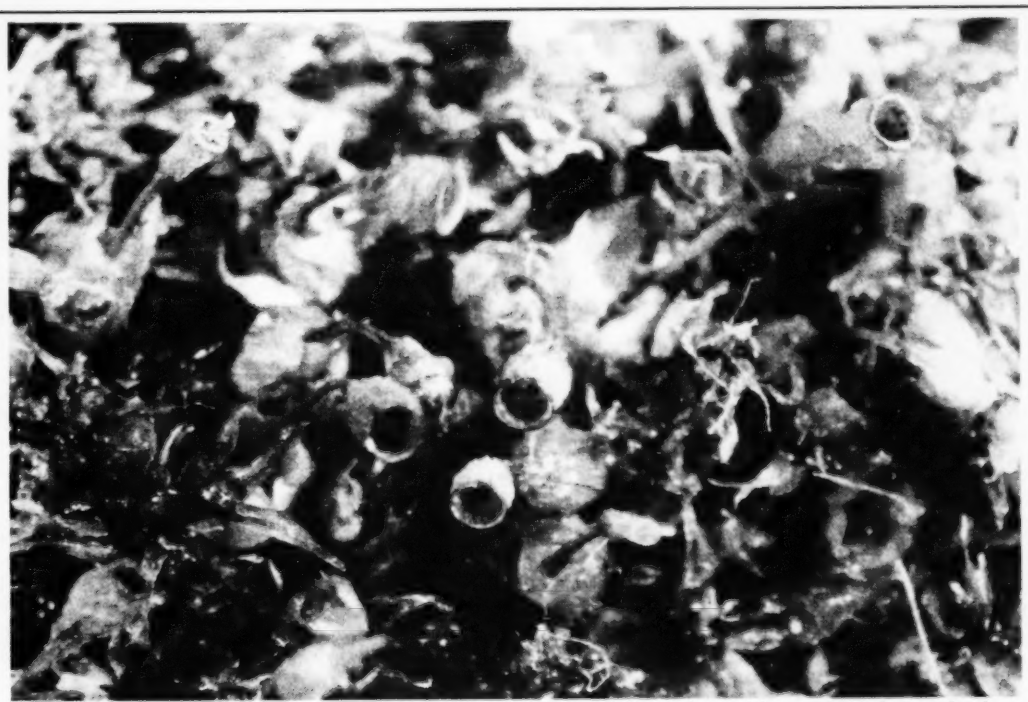

Figure 22. Plants of *Physcomitrium hookeri*. This tiny, broad-leaved plant with urn-shaped capsules is nationally rare. (Jennifer Doubt)

Description: *Physcomitrium hookeri* is a tiny (1-2 mm high), light- to brownish-green moss, with relatively broad leaves (Figure 22). Its round, urn-like capsules (1-1.5 mm long) are its most recognizable feature in the field. *P. hookeri* is differentiated from other species of *Physcomitrium* by entire (rather than serrulate) leaves and a large, dehiscent annulus (cells that attach the capsule's lid to the capsule) (Figure 23).

Distribution: *P. hookeri* is endemic to North America and it is uncommon throughout its range (Crum & Anderson 1981). The species' range reportedly extends from Alberta to Ontario, and south to Utah, Wyoming, Nebraska, Iowa, and Wisconsin (Crum & Anderson 1981). However, Ireland and Ley (1992) do not list *P. hookeri* in their atlas of Ontario mosses. Belland (1998) lists *P. hookeri* among the rare mosses of Canada, ranking it N1 (known from five or fewer occurrences nationwide). He reports that *P. hookeri* has been found only in Alberta and Manitoba, and the author has seen only Alberta and Manitoba specimens (herbaria at the Univeristy of Alberta (ALTA), the Provincial Museum of Alberta (PMA), and the Canadia Museum of Nature (CANM) (Figure 24). In Alberta, two collections of *P. hookeri* were taken by A.H. Brinkman in Calgary near the turn of the century, and D.H. Vitt collected the species near Fort Saskatchewan in 1971 (ANHIC files). Globally, the species is ranked G2G4 (Belland 1998), indicating uncertainty concerning the global population: G2 indicates fewer than 20 occurrences worldwide and that the species may be especially vulnerable to extirpation, and G4 refers to species with more than 100 occurrences with apparently secure populations. The Beta Lake occurrence of *P. hookeri* is therefore significant at provincial, national, and global levels.

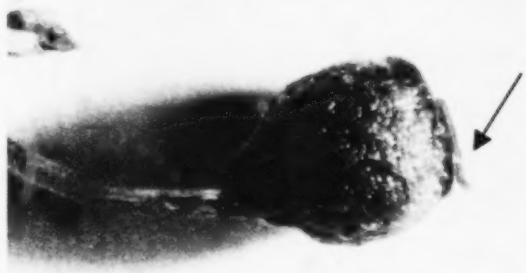

Figure 23. In *Physcomitrium hookeri* a row of cells around the mouth of the capsule (the 'annulus') peels readily away (indicated by arrow). (Jennifer Doubt)

Habitat: This population of *P. hookeri* was observed high on the steep, under-cut, 2m-high banks of a slow-moving, meandering, muddy stream east of Beta Lake, in the Beta Lake Natural Area. The species was especially prominent among the graminoid species overhanging the top of the bank. This habitat appears to be typical of *P. hookeri*; Crum and Anderson (1981) report that the species prefers the wet soil of floodplains and the banks of roads or streams. Calgary specimens of *P. hookeri* were collected from mud associated with a dried marsh bed, and the Fort Saskatchewan specimen was collected 'along [a] road'. These habitats appear to

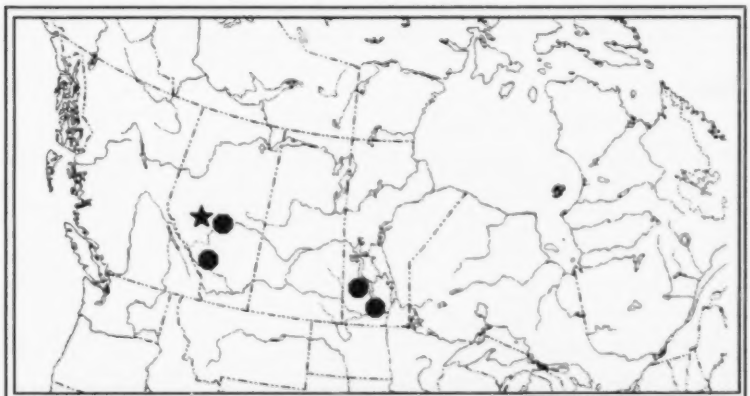

Figure 24. Approximate Canadian distribution of *Physcomitrium hookeri*. The star indicates the location of the Beta Lake population.

be subject to sudden hydrological change, and populations may frequently be eliminated and re-establish elsewhere.

Population: *Physcomitrium hookeri* appeared to be quite abundant (scattered along at least several meters of the stream bank) at the Beta Lake site, although no data were recorded because the rarity of the species was unknown at the time of collection. Capsules at all stages of development are present in the collections made.

Threats / Recommendations: *P. hookeri* is currently protected within Beta Lake Natural Area. Little evidence of human disturbance was noted at the site. Like other species with affinities for temporary substrates with short disturbance intervals, however, populations of *P. hookeri* may tend to fluctuate often or to disperse frequently to freshly-created favourable habitats. It is important to complete the assessment of the Beta Lake population as soon as possible and to monitor it frequently. Flooding in July 2001 disturbed all stream habitats in the area soon after *P. hookeri* was collected, and may have already altered the Beta Lake population. Examination and monitoring of similar habitats in the vicinity may yield new records for the species and aid in understanding the local population dynamics. Current upstream human developments and the potential impact of changes to upstream habitats should be investigated.

Specimens: J. Doubt #7496, 7501, 7503 (June 26, 2001), Devonian Botanic Garden

***Pogonatum dentatum***

**Hair-like pogonatum, Hair-like hair-cap** **S2S3**

| | |
|---|---|
| Location | Whitecourt Mountain Natural Area |
| Habitats | Mature forest with little human disturbance, dominated by lodgepole pine (*Pinus contorta*), on sand exposed by fallen tree<br>On sandy, vertical, roadside soil shaded by young aspen (*Populus tremuloides*) stand. |
| Recommendations | Monitor populations and habitats<br>Maintain mature forest habitat in Whitecourt Mountain Natural Area |

Description: *Pogonatum dentatum* belongs to the group of mosses (*Polytrichum, Polytrichastrum, Pogonatum*) that resemble miniature conifers. *P. dentatum* reaches 1-4.5 cm tall, with dull, toothed, blue-green, flat leaves (2.5-4.5 mm long) (Figure 25).

Distribution: *P. dentatum* is described as an "arctic-montane species of scattered distribution", which traces an inverted 'U' across North America, extending south to Oregon and North Carolina in the west and east, respectively (Hassel 2000). Seventeen locations for *P. dentatum* are listed by ANHIC (2001) (Figure 26). Nine of these are in the mountains, largely in Jasper National Park. The species is also known from the Swan Hills and from Whitecourt. Whitecourt collections were made in 1964

and 1972; the current study confirms the species' persistence in the area, although the site is also far enough from recorded locations to constitute a new occurrence.

In Europe, the range of *Pogonatum dentatum* has expanded recently, as forestry activities have provided large areas of suitable habitat (Hassel 2000). No effort has been made to detect the phenomenon in North America.

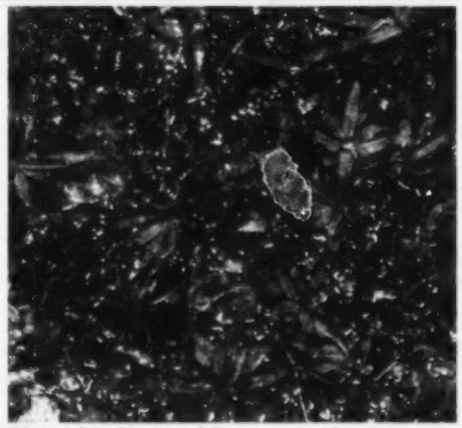

Figure 25. Plants of *Pogonatum dentatum*. Members of this genus resemble minature conifers. (Jennifer Doubt)

Habitat: *P. dentatum* was discovered at two sites in Whitecourt Mountain Natural Area. Both populations were on exposed sand - one on a natural 'tip-up' exposed by a fallen tree (Figure 27) in a coniferous forest (Figure 7), and one on the vertical soil of a road-cut, below a young aspen (*Populus tremuloides*) forest and above a ditch.

The habitats in which *P. dentatum* was found in this study are typical of the species. Other Alberta populations were also collected from exposed soil, especially that at the bases of fallen trees, beside trails and roads, and along streams (ANHIC files). Furthermore, *P. dentatum* prefers non-calcareous rocks or soil (Crum & Anderson 1981). The acidophile *H. ochraceum* was also collected from Whitecourt Mountain, suggesting that the chemistry of the site differs from most other areas sampled, resulting in unique growing conditions. The elevation of Whitecourt Mountain compared with lowlands to the east is also in keeping with the affinity of *P. dentatum* for mountainous regions in the southern part of its range.

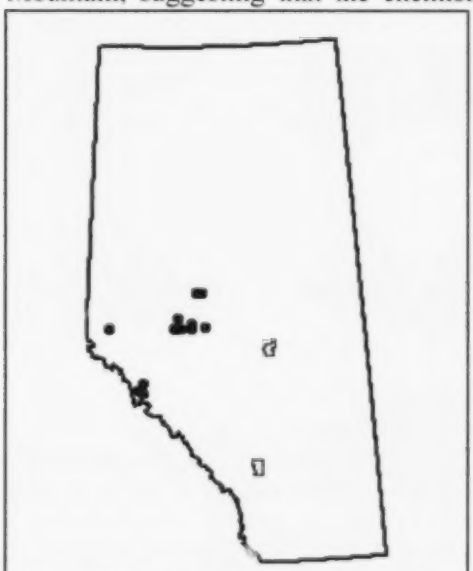

Figure 26. Known Alberta distribution of *Pogonatum dentatum*.

Hassel (2000) describes *P. dentatum* as a colonist of disturbed soil, occurring in the early stages of secondary succession. The species doesn't compete well with other species, and must move to new sites as more plants establish themselves. At least one population of *P. dentatum* in this study owes its habitat to human activity (road construction), and the proliferation of human activity in forested Alberta could make *P. dentatum* more common in the future (see Hassel 2000).

Populations: The tip-up population measured approximately 900 $cm^2$. Along the road cut, *P. dentatum* occupied about 225 $cm^2$. No fruiting bodies were observed. On the tip-up, *P. dentatum* was found intermixed with another rare species (*Dicranella heteromalla*) (Figure 27), and was in close proximity to a third (*Brachythecium rutabulum*).

Threats / Recommendations: *P. dentatum* is protected to some extent by the Natural Area designation of the top of Whitecourt Mountain. While fresh disturbance such as the construction of new roads may increase population numbers, road improvements that eliminate the vertical soil banks now present near the top of the mountain could, on the other hand, eliminate populations. Monitoring roadside populations may be of some value in this respect. Because the species is expected to disappear on older instances of disturbed soil and to re-appear on new ones, monitoring of the entire pine forest habitat in addition to the individual population is important. The maintenance of mature forests on sandy sites, where natural windfall is a regular occurrence, will help *P. dentatum* to persist by providing fresh substrates to which the species can disperse.

Figure 27. *Pogonatum dentatum* (indicated by large arrow) growing interspersed with another rare moss, *Dicranella heteromalla* (indicated by small arrow) on the soil exposed among the roots of a fallen tree. (Steve Bradbury)

Specimens: J. Doubt #7623 (June 28, 2001), 7802 (August 2, 2001), Devonian Botanic Garden

***Rhizomnium magnifolium***

**Large-leaved mnium, Large-leaf hairy-lantern moss, Large round moss** **S2**

Location .....Whitecourt Mountain
Habitat.....Wet humus beside slow-moving stream
Recommendations.....Re-visit site to complete population assessment
Monitor population
Investigate stream habitats upstream and downstream from population to assess potential threats and to search for more populations

Description: *Rhizomnium magnifolium* is a relatively large moss with broad (4 - 6.5 mm wide), elliptic leaves (to 12 mm long) (Figure 28). Leaves of *Rhizomnium* species lack marginal teeth, differentiating them from leaves of the superficially-similar genera *Mnium* and *Plagiomnium*.

Distribution: Although *R. magnifolium* is ranked S2 in Alberta, ANHIC did not possess any records for the species at the time of this report. Investigation of herbarium records at the University of Alberta (ALTA) and at the Provincial museum of Alberta (PMA) resulted in the discovery of specimens for about 25 Alberta occurrences (Figure 29). At least four of these were recorded near the study area, all in the 1960's: three in the Swan Hills vicinity, and one west-south-west of Whitecourt. The Whitecourt Mountain population discovered in association with the current study is therefore important in confirming the persistence of *R. magnifolium* in the area.

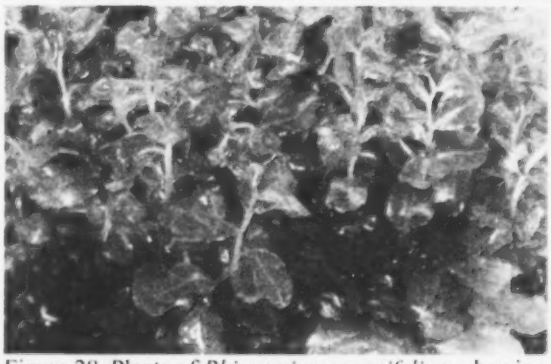

Figure 28. Plants of *Rhizomnium magnifolium*, showing broad, elliptic, untoothed leaves. (Jennifer Doubt)

In North America, populations of *R. magnifolium* occur in the west from Alaska south to California and New Mexico, and in the east, inland to Lake Superior and south to southern Ontario and Maine (Crum & Anderson 1981, Koponen 1973).

Habitat: The Whitecourt Mountain occurrence of *R. magnifolium* reflects its preference for "wet habitats and woodlands, around springs, brooks and seepages, often growing partly submerged" (Koponen 1973). The stream in which *R. magnifolium* occurrs flows through a moist aspen (*Populus*) stand downstream of a grass-covered cut line well-travelled by recreational vehicles.

Population: The extent of the Whitecourt Mountain population was not assessed fully, as the rarity of the specimen was not recognized at the time of collection. *R. magnifolium* was abundant at the Whitecourt Mountain site, occupying at least 1 $m^2$ of area. No fruiting bodies were seen. *R. magnifolium* occurred in the same stream as *Hygrohypnum molle* and *Hygrohypnum ochraceum* – two other rare mosses.

Threats / Recommendations: The site occurs just west of the Whitecourt Mountain Natural Area, and as such is not officially protected. The section of stream on which *R. magnifolium* was discovered is

Figure 29. Known Alberta distribution of *Rhizomnium magnifolium*.

downstream from a cut-line that appears to be used by recreational vehicles. Monitoring of the habitat and the population is recommended. Initial return visits to the site should involve travelling further in either direction along the stream to assess both the extent of occurrence of all local rare species and to search for new rare species. This assessment will also facilitate the evaluation of potential threats to the populations posed by human activity along the nearby cut-line.

Specimens: J. Doubt #7668 (June 28, 2001), Devonian Botanic Garden

***Splachnum ampullaceum***

**Flagon-fruited collar moss, Common kettle moss, Cow moss** **S2**

| | |
|---|---|
| Locations | Whitecourt area<br>South-west of Mayerthorpe |
| Habitats | Black-spruce dominated peatland<br>Willow-dominated wetland |
| Recommendations | Be vigilant for *S. ampullaceum* in Alberta peatlands to monitor its persistence and local distribution over time |

Description: Members of the genus *Splachnum* grow on organic substrates, especially dung, and are adapted to insect-assisted dispersal between temporary substrates. They generate tall, often colourful, umbrella-shaped sporophytes (fruiting bodies), release insect-attracting odours, and produce sticky spores (Marino 1988). Species of *Splachnum* are generally differentiated based on sporophyte characters, but *Splachnum ampullaceum* is one of few species that can be readily identified without sporophytes due to the presence of long, multi-celled teeth on the leaf margins (Figure 30).

Figure 30. Plant of *Splachnum ampullaceum*, a dung moss distinguishable by the large marginal teeth on the leaves (indicated on

Distribution: *S. ampullaceum* was collected from two locales near the north-east and north-west corners of the study area. Neither of these locations was previously recorded for the species. Fourteen widely-ranging Alberta occurrences of *S. ampullaceum*, including several near the Whitecourt study area (Shiningbank Lake, Wabamun, Glenevis), are listed with ANHIC (Figure 31). None of these populations were sought for the current study.

In North America, *S. ampullaceum* is found in boreal and montane regions from the Atlantic to the Pacific (Marino 1988). It is most common, however, east from Ontario and New England (Marino 1988). In the west, it reportedly becomes quite infrequent, although Alberta has the largest number of known occurrences of any western province or territory. Because it is less conspicuous and more difficult to identify when it is not fruiting, and because peatland habitats are generally bryologically unremarkable (leading to undercollection), the frequency of *S. ampullaceum* in Alberta may be underestimated.

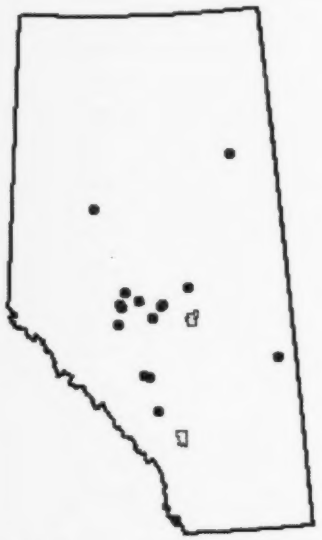

Figure 31. Known Alberta distribution of *Splachnum ampullaceum*.

Habitat: Both populations of *S. ampullaceum* were collected from what appeared to be moose dung. The collection near Whitecourt was made in a treed fen (Figure 32), while the population near Mayerthorpe was growing in a moist willow-graminoid community. *Splachnum* species are known to grow primarily in peatlands. As the dung that the species inhabits changes rapidly over time, *S. ampullaceum* is forced to colonize new microhabitats and produce sporophytes within relatively short intervals. This makes searching for the species difficult in that precision in recording the location of a population may not help at all in re-discovering it: any given population will have dispersed to a new dung deposit in a year or two.

Population: Only one colony of *S. ampullaceum* was found at each of the two sites in this study, each of which occupied the extent of one deposit of dung. Immature fruiting bodies were seen on the specimen from the willow-dominated site, and this population was mixed with another (unidentifiable) species of *Splachnum*.

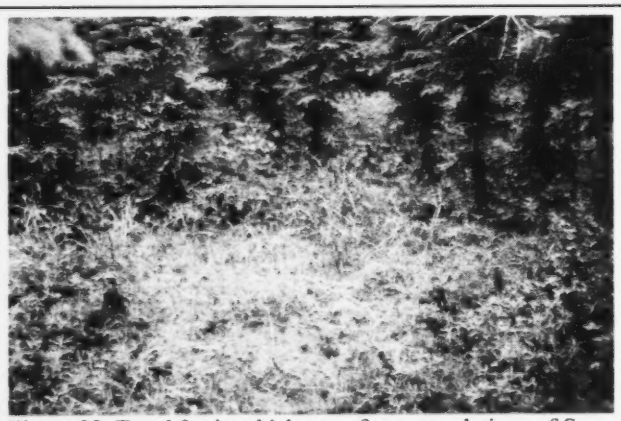

Figure 32. Treed fen in which one of two populations of *S. ampullaceum* was discovered in this study. (Steve Bradbury)

Threats / Recommendations: No threats to the populations discovered in this study were identified, as peatlands are generally less attractive to human development and

activity than other habitats in the study area. The species should persist in moist habitats frequented by ungulates throughout the study area. Monitoring of the populations is not practical because of the short life of individual colonies. It is recommended instead that collectors be vigilant for dung mosses in Alberta peatlands so that the persistence and distribution of *S. ampullaceum* in the area may be confirmed over time.

Specimens: J. Doubt #7557 (June 27, 2001), 7708A (June 29, 2001), Devonian Botanic Garden

## 5.0 RECOMMENDATIONS

Recommendations resulting from this study with respect to the assessment and protection of rare plant populations in the Whitecourt Study Area, the execution of future surveys, and sites for further investigation both within and beyond the Whitecourt study area are summarized in Table 3, and are discussed in the remainder of the report.

Table 3. Summary of recommendations resulting from the rare plant survey.

| Details | Recommendation |
|---|---|
| *Rare plant populations* | |
| Sections 4.4, 5.1 | **Re-visit all populations** to complete population and habitat assessments. |
| | **Monitor all populations** at intervals that reflect the pace of natural and anthropogenic habitat change. |
| | **Maintain habitat character and diversity** of protected areas, especially Whitecourt Mountain, which housed many rare species. |
| *Logistical considerations in future rare plant surveys* | |
| Sections 4.1, 4.2, 4.3, 4.2.1 | **Establish and formalize priorities with respect to species capture vs. detailed assessment of individual populations,** as time constraints are likely to prohibit thorough inventories of large study areas. |
| | **Allow for different sampling approaches for vascular and non-vascular plants**, in terms of sampling techniques and schedules. |
| | **Make repeat visits to sites over the growing season** to capture plants at different stages of development (especially for vascular plants) and to assess populations of plants once their rarity has been determined (especially for non-vascular plants). |
| | **Sample over two or more growing seasons.** |
| *Target sites and locales in the Whitecourt study area* | |
| Sections 4.4, 5.2.2, Appendix 3 | **Sample regions that were under-represented in the current study.** |
| | **Sample landscape features that were under-represented in the current study.** |
| | **Sample Highway and Paddle River Natural Areas**, which were recommended for sampling but which were not visited in the current study. |
| | **Visit, and if appropriate, sample promising sites that were flagged in the current study** but that could not be visited due to time constraints. |
| | **Re-visit sites where potentially rare plants were observed**, but where positive identification of these plants was not possible. |
| *New study areas* | |
| 5.2.3 | **Focus on regions of Alberta that are not well-collected and that experience heavy or increasing human disturbance**, such as boreal forest and prairie regions. |

## 5.1 General recommendations for rare plant populations

Specific recommendations for the populations of rare species discovered in this survey are outlined in the discussions of each species in section 4.4. Three generalizations may be made regarding these recommendations.

1. The rarity of most rare bryophyte species in this study was not recognized until laboratory examination of vouchers was complete. For populations of these species, follow-up visits to complete the assessment of the extent and vigour of the populations and their habitats are recommended. During these visits, it is also important to examine the positive and negative influences of human activity on these populations: although most rare plant populations in this study were discovered in protected areas, several populations may be affected by the cessation or alteration of human activity.

2. It is recommended that all rare plant populations be monitored at intervals that reflect the pace of natural and anthropogenic habitat change. Species that occupy very temporary, frequently-disturbed, or threatened habitats should be monitored more frequently than perennial species occupying stable, protected habitats. Belland et al. (1996), for example, recommend a minimum interval of 5 years in Elk Island National Park.

3. Protected areas featured important habitats for rare species in this study, and their preservation is important to rare species persistence. Whitecourt Mountain in general and Whitecourt Mountain Natural Area in particular proved to be rich in rare non-vascular plant species. Because the Natural Area supports several rare species in a relatively small area, attention should be devoted to maintaining the character and diversity of habitats present at the site, including coniferous forests, mature forests, acid rocky streams, and disturbed sand, which are otherwise quite uncommon in the Whitecourt study area.

## 5.2 Recommendations for future surveys

### 5.2.1 Logistical considerations of working with vascular and non-vascular plants

The inclusion of non-vascular plants in the current study represents a considerable advance over most rare plant surveys. Bryophytes constitute a significant proportion of plant diversity in the province, and they contribute significantly to ecosystem functioning, yet they are often over-looked. Non-vascular plants should be included in future surveys, and survey protocols should be adapted to reflect the particularities of working with different target plant groups.

4. In general rare vascular and non-vascular plants require different sampling approaches because of differences in their ecology and in the techniques required to collect and identify them. Different landscape features are most likely to

support rare species in each group (section 4.2), for example. Furthermore, very few days of field work collecting bryophytes can result in many days of lab work to complete identifications, whereas a much larger proportion of vascular plants can be identified in the field. The particularities of vascular and non-vascular plant work should be accounted for in the planning and scheduling phases of rare plant surveys.

5. Rare bryophyte surveys are complicated by the necessity of microscope work to determine rarity. This requires that either *every* population from which a sample is collected be documented in detail with respect to habitat, abundance, vigour, etc., or that sites found to house rare species must be visited a second time to complete the detailed work. Additional time spent on redundant assessments or on re-accessing populations of rare species diminishes the total number of sites accessed in the survey, and thus the number of rare plant populations detected. If detailed population assessments are deemed less important than capturing more rare species populations, it may be useful to define a 'minimum habitat description' (e.g. photograph, dominant overstory and understory vascular plants, obvious human threats and impacts, etc.) that must be completed for every site regardless of the confirmed presence of rare species. For the current survey, it is recommended that rare non-vascular plant populations be visited again in the next growing season to complete detailed assessments. In future surveys, it is recommended that the priorities of the study with respect to the relative importance of capturing few, well-documented rare bryophyte populations (through repeat site visits) as opposed to discovering many known locations for rare species should be established, and be accounted for in work schedules and budgets.

6. In future surveys, repeat site visits over the growing season should also be considered in order to capture plants at varying stages of development. This is particularly important for vascular plants (section 4.3), but several potentially rare non-vascular plants observed in this study could not be identified because they were not yet mature. By capturing a range of flowering and fruiting times, the chances of detecting rare species are increased. Again, it is important to establish priorities regarding the relative importance of seasonal versus geographic coverage.

7. The Alberta Native Plant Council (2000) also recommends that rare vascular plant surveys be conducted over more than one growing season, as population sizes fluctuate from year to year, and some species that are present may be found only in the seed bank in a given sampling year.

### 5.2.2 Recommended target sites and locales in the Whitecourt study area

The Whitecourt study area is large, and time constraints prohibited a complete inventory of rare plant species in 2001. Future sampling will undoubtedly reveal the

presence of more rare plants there. Adding to the findings of the current study by seeking and documenting more populations and more species within the Whitecourt study area will help managers to determine the relative significance of individual species and populations when making land-use decisions. The following suggestions for future sampling sites in the Whitecourt study area were developed from the experience of plant specialists in the current survey, and are listed in detail in Appendix 3.

8. Although attempts were made in the current study area to sample sites representing the full geographical range in the Whitecourt study area, some regions were under-represented. These regions should receive priority in future work.

9. Certain landscape features suggested for emphasis by Cornish (2001) were under-represented in the current study. These landscape features should receive greater emphasis in future survey work in the Whitecourt study area. Other landscape features proved to be more important for rare species than anticipated when the original sampling scheme was developed, and these should also receive greater attention in future surveys.

   Furthermore , July flooding of watercourses disturbed river and stream bank habitats throughout the Whitecourt study area, burying many plant populations in mud. River and stream banks should be the focus of future rare plant studies in the current study area, as they have the potential to support several rare species (such as, in particular, the nationally rare *Physcomitrium hookeri*), and conditions prevented their thorough sampling.

10. Provincial Natural Areas were identified as priority sampling sites, but due to access difficulties Highway and Paddle River Natural Areas were not visited in the current study. These locales should be sampled. Whitecourt Natural Area and Pembina River Provincial Park also feature many unexplored and potentially rewarding habitats.

11. Of the sites identified (using air photos and topographic maps) as promising target sites at the beginning of the study, several remain unexplored. A list is provided in Appendix 3.

12. Sites where potentially rare, but unidentifiable vascular and non-vascular plants were observed should be visited again in the hopes of determining the rarity of the species.

### 5.2.3 Recommended target study areas

The lower foothills study area was an excellent focus for a rare plant survey. Its climatically and vegetationally transitional nature allowed for the discovery of species at

their range limits, and for a wide variety of growing conditions producing high plant diversity. The high intensity of human activity in the area made the timely assessment of rare plant populations critical to their protection. The reputation of the region for being floristically unremarkable meant that it had attracted little botanical attention and was quite floristically unknown.

13. Factors justifying the urgency of rare plant survey work in the Whitecourt study area may be applied to the selection of future survey areas. The boreal forest of northern Alberta and Alberta prairie habitats, for example, suffer from a lack of plant collecting, and are subject to significant ongoing anthropogenic change.

## 6.0 REFERENCES CITED


ANPC (Alberta Native Plant Council). 2000. ANPC Guidelines for Rare Plant Surveys in Alberta. March Information Bulletin.

Anderson, L.E. 1990. A checklist of Sphagnum in North America North of Mexico. Bryologist 93: 500-501.

Anderson, L.E., H.A. Crum, & W.R. Buck. 1990. List of the mosses of North America north of Mexico. Bryologist 93: 448-499.

ANHIC (Alberta Natural Heritage Information Centre). 2001. Mosses, Liverworts & Hornworts Tracking List. Online: http://www3.gov.ab.ca/env/parks/anhic/nonvastk.html.

Beckingham, J.D. & J.H. Archibald. 1996. *Field Guide to the Ecosites of Northern Alberta.* UBC Press, Vancouver, Canada.

Beckingham, J.D., I.G.W. Corns, & J.H. Archibald. 1996. Field Guide to the Ecosites of West-central Alberta. UBC Press, Vancouver, Canada.

Belland, R.J. 1998. The Rare Mosses of Canada – A Review and First Listing. Committee on the Status of Endangered Wildlife in Canada (COSEWIC), Ottawa, Canada. 91 pp.

Belland, R.J., D.H. Vitt & L. Sigler 1996. A Methodology and Terms of Reference for a Non-Vascular Cryptogam Inventory and Monitoring Programme in Elk Island National Park. Unpubl. Contract Report for Elk Island National Park, AB.

Bird, C.D. 1978. Keys to the lichens of west-central Canada. Department of Biology, University of Calgary, Calgary, Alberta. 171 pp.

Brodo, I.M., S.D. Sharnoff, & S. Sharnoff. 2001. Lichens of North America. Yale University Press, New Haven, U.S.A. 795 pp.

Cornish, B. 2001. Proposed Protocol for a Rare Plant Survey in a Lower Foothills Study Area in the Northern East Slopes. Interim Report. Alberta Sustainable Resource Development, Fish and Wildlife Management Division, Edmonton, Alberta.

Crum, H. 1984. Sphagnopsida, Sphagnaceae. North American Flora Series II. The New York Botanical Garden, New York, U.S.A. 180 pp.

Crum, H.A. & L.E. Anderson. 1981. Mosses of Eastern North America. Columbia University Press, New York, U.S.A. 1328 pp.

Delgadillo, C. 1975.Taxonomic revision of *Aloina, Aloinella*, and *Crossidium* (Musci). The Bryologist 78:245-303.

Dirkse, G.M. & G.F.P. Martakis. 1998. Species density of phanerogams and bryophytes in Dutch forests. Biodiversity and Conservation 7:147-157.

Downing, D. 1999. Summary: Eastern Slopes Region Benchmark Program Results 1993-1998. Alberta Environmental Protection / Alberta Agriculture, Food, and Rural Development, Edmonton, Canada.

Esslinger, T.L. 1997. A cumulative checklist for the lichen-forming, lichenicolous and allied fungi of the continental United States and Canada. North Dakota State University: http://www.ndsu.nodak.edu/instruct/esslinge/chcklst7.htm (updated August 2001), Fargo, North Dakota.

Environmental Management Associates. 1993. Deciduous Forest Types of the Lower Boreal Cordilleran Ecoregion, West Central Alberta (First Approximation). Alberta Forestry, Lands and Wildlife, Edmonton, Canada. 159 pp.

Glime J. 1989. Should mosses have common names? Evansia 6:1-6.

Glime, J. 1991. Should mosses have common names? Part 5. The common names of Pottiales. Evansia 8:32-37.

Glime, J. 1992. Should mosses have common names? Part 7. The common names of Funariales. Evansia 9:45-48.

Glime J. 1993. Should mosses have common names? Part 8. The common names of Bryales. Evansia 10:1-8.

Glime, J. 1994a. Should mosses have common names? Part 10. The common names of Leucodontales. Evansia 11:30-34.

Glime, J. 1994b. Should mosses have common names? Part 12. The common names of Hypnales. Evansia 11:102-114.

Glime J. & Zhang 1990. Should mosses have common names? Part 4. The Dicranales. Evansia 7:41-46.

Goffinet, G. & R.I. Hastings. 1994. The lichen genus Peltigera (lichenized ascomycetes) in Alberta. Natural History Occasional Paper No. 21, Provincial Museum of Alberta, Edmonton, Alberta. 54 pp.

Goward, T. 1999. The Lichens of British Columbia. Illustrated Keys. Part 2 – Fruticose Species. Special Report Series No. 9, B.C. Ministry of Forests, Victoria, British Columbia.

Goward, T., B. McCune, & D. Meidinger. 1994. The lichens of British Columbia. Illustrated Keys. Part 1 – Foliose and Squamulose Species. Special Report Series No. 8, B.C. Ministry of Forests, Victoria, British Columbia.

Hassel, K. 2000. Bryophyte Profiles 2. Pogonatum dentatum (Brid.) Brid. (Bryopsida: Polytrichaceae). Journal of Bryology 22: 55-60.

Ireland, R.R. & L.M. Ley. 1992. Atlas of Ontario Mosses, Syllogeus 70, Canadian Museum of Nature, Ottawa, Canada. 138 pp.

Koponen, T. 1974. A guide to the Mniaceae in Canada. Lindbergia 2: 160-184.

Lawton, E. 1971. Moss Flora of the Pacific Northwest. Hattori Botanical Laboratory, Nichinan, Miyazaki, Japan. 389 pp.

Lesko, G.L. & J.D. Lindsay. 1973. Forest/Soil Relationships and Management Consideration in a Portion of the Chip Lake Map Area, Alberta. Alberta Research Council Earth Sciences Report 73-1, Edmonton, Canada. 66 pp.

Marino, P.C. 1988. The North American distributions of the circumboreal species of *Splachnum* and *Tetraplodon*. The Bryologist 91:161-166.

Moss, E.H. 1983. Flora of Alberta, 2nd Ed. University of Toronto Press, Toronto, Canada. 687 pp.

Nyholm, E. 1954. Illustrated Moss Flora of Fennoscandia II. Musci. CWK Gleerup, Lund, Sweden. 799 pp.

Peterson, W. 1979. A Revision of the Genera Dicranum and Orthodicranum (Musci) in North America North of Mexico. Ph.D. Thesis, Department of Botany, University of Alberta, Edmonton, Canada.

Pharo, E.J., A.J. Beattie, & D.Binns. 1999. Vascular plant diversity as a surrogate for bryophyte and lichen diversity. Conservation Biology 13:282-292.

Schuster, R.M. 1977. Boreal Hepaticae: A Manual of the Liverworts of Minnesota and Adjacent Regions. J. Cramer, Hirschberg, Germany. 332 pp.

Thomson, J.W. 1984. American Arctic Lichens. 1. The Macrolichens. Columbia University Press, New York, New York.

Thomson, J.W. 1997. American Arctic Lichens. 2. The Microlichens. University of Wisconsin Press, Madiscon, Wisconsin.

Twardy, A.G. & J.D. Lindsay. 1971. Reconnaissance Soil Survey of the Chip Lake Area. Research Council of Alberta Report No. 91. University of Alberta, Edmonton, Canada. 71 pp.

Wynnyk, A., J.D. Lindsay, & W. Odynsky. 1969. Soil Survey of the Whitecourt and Barrhead Area. Research Council of Alberta Report No. 90. University of Alberta, Edmonton, Canada. 68 pp.

Vitt, D.H. & R.J. Belland. 1997. Attributes of rarity among Alberta mosses: Patterns and predictions of species diversity. The Bryologist 100: 1-12.

# 7.0 APPENDICES

**Appendix 1.** Non-vascular plants and lichens recorded during the rare plant survey in the Whitecourt study area.
(Rare species are marked with asterisks. Numbers across the top of the table correspond to site numbers used for this study.
Data is given only for sites in which samples were identified to species; these are not complete species lists for each site).

| | 1.1 | 1.2 | 1.3 | 1.5 | 2.1 | 2.2 | 3.1 | 3.3 | 3.4 | 4.1 | 6.1 | 6.2 | 6.3 | 7.1 | 8.1 | 8.2 | 8.3 | 9.1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Mosses** | | | | | | | | | | | | | | | | | | |
| *Abietinella abietinum* | | | | | | | | | | | | | | | | | | |
| *Aloina rigida** | | | | | | | | | | | | | | | | | | |
| *Amblystegium serpens* | | | | 1 | | 1 | | | | | | | | | | | | |
| *Atrichum selwynii* | | | | | | | | | | | | | | | | | | |
| *Aulacomnium palustre* | | | | | | | | | | 1 | | | | 1 | | | | |
| *Barbula unguiculata* | | | | | | | | | | | 1 | | | | | | | |
| *Brachythecium rivulare* | | | | | | | | | | | | | | | | | | |
| *Brachythecium rutabulum** | | | | | | | | | | | | | | | | | | |
| *Brachythecium salebrosum* | | | | | | | | | | | | | | | | | | |
| *Brachythecium starkei* | | | | | | | | | | | | | | | | | | |
| *Brachythecium turgidum* | | | | 1 | | | | | | | | | | | | | | |
| *Bryoerythrophyllum recurvirostre* | | | | | | 1 | | | | | | 1 | | | | | | |
| *Bryohaplocladium microphyllum* | | | | | | | | | | | | | | | | | | |
| *Bryum argenteum* | | | | | | | | | | | | | | | | | | |
| *Bryum capillare* | | | | | | | | | | | | | | | | | | |
| *Bryum lisae* var. *cuspidatum* | | | | | | | | | | | | | | | | | | |
| *Bryum pseudotriquetrum* | | | | 1 | | | | | | | | | | | | | | |
| *Calliergon cordifolium* | | | | | | | | | | | | | | | | | | |
| *Campylium hispidulum* | | | | | | | | | | | | | | | | | | |
| *Ceratodon purpureus* | 1 | | | | | | | | 1 | 1 | | | | | | | | |
| *Climacium dendroides* | | | | | | | | | | | | | | | 1 | | | |
| *Cratoneuron filicinum* | | | | | | | | | | | | | | | | | | |
| *Dicranella heteromalla** | | | | | | | | | | | | | | | | | | |
| *Dicranella subulata** | | | | | | | | | | | | | | | | | | |
| *Dicranella varia* | | | | | | | | | | | | | | | | | 1 | |
| *Dicranum flagellare* | | | | | | | | | | | | | | | | | | |
| *Dicranum fragilifolium* | | | | | | | | | | | | | | | | | | |
| *Dicranum polysetum* | | | | | | | | | | | | | | | | | | 1 |
| *Dicranum undulatum* | 1 | | | | | | | | | 1 | | | | | | | | |
| *Distichium capillaceum* | | | | | 1 | | | | | | | | | 1 | | 1 | | |
| *Drepanocladus aduncus* | | | | 1 | | | | | 1 | | | | | | | | | |
| *Eurhynchium pulchellum* | | | | | 1 | | | | | | | | 1 | | | | | |
| *Funaria hygrometrica* | | | | | | | | | | | | | | | | | | |
| *Hygrohypnum molle** | | | | | | | | | | | | | | | | | | |

Appendix 1 (continued)

| | 1.1 | 1.2 | 1.3 | 1.5 | 2.1 | 2.2 | 3.1 | 3.3 | 3.4 | 4.1 | 6.1 | 6.2 | 6.3 | 7.1 | 8.1 | 8.2 | 8.3 | 9.1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Hygrohypnum ochraceum** | | | | | | | | | | | | | | | | | | |
| *Hylocomium splendens* | 1 | | | | | | 1 | | | 1 | | | | | 1 | | | 1 |
| *Hypnum lindbergii* | | | | | | | | | | | 1 | | | | | | | |
| *Hypnum pallescens** | | | | | | | | | | | | | | 1 | | | | |
| *Hypnum pratense* | | | | | | | | | | | | | | | | | | |
| *Isopterygiopsis pulchella* | | | | | | | | | | | | | | | | | | |
| *Leptobryum pyriforme* | | | | | | | | 1 | 1 | | | | | | | | | |
| *Leptodictyum riparium* | | | | | | | | | | | | | | | | | | |
| *Limprichtia revolvens* | | | | | | | | | | 1 | | | | 1 | | 1 | | |
| *Myurella julacea* | | | | | | | | | | | | | | | | | | |
| *Neckera pennata** | | | | | | | | | | | | | | | | | | |
| *Onchophorus wahlenbergii* | | | | | | | | | | | | | | | | | | |
| *Oncophorus virens* var. *serrata* | | | | | | | | | | | | | | | | | | |
| *Orthotrichum obtusifolium* | | | | | | | | | | | | | | | | | | |
| *Orthotrichum speciosum* | | | | | | | | | | | | | | | | | | |
| *Physcomitrium hookeri** | | | | | | | | 1 | | | | | | | | | | |
| *Plagiomium cuspidatum* | | | | | | 1 | | | | | | | | | 1 | | | |
| *Plagiomnium ellipticum* | | | | | | | | | | | | | | | | | | |
| *Platygyrium repens* | | | | | | | | | | | | | | | | | | |
| *Playdictya jungermannioides* | | | | | | | | | | | | | | 1 | | | | |
| *Pleurozium schreberi* | 1 | | 1 | | 1 | | 1 | | | 1 | | | | | | | | 1 |
| *Pogonatum dentatum** | | | | | | | | | | | | | | | | | | |
| *Pohlia cruda* | | | | | | | | | | | | | | | | | | |
| *Pohlia nutans* | | | | | | | | | | | | | | 1 | | | | |
| *Pohlia proligera* | | | | | | | | | | | | | | | | | | |
| *Pohlia wahlenbergii* | | | | | | | | | | | | | | | | | | |
| *Polytrichum commune* | | | | | | | | | | | | | | | | | | |
| *Polytrichum juniperinum* | 1 | | | | | | | | | | | | | | | | | |
| *Polytrichum piliferum* | | | | | | | | | | | | | | | | | | |
| *Polytrichum strictum* | | | 1 | | | | | | | 1 | | | | | | | | |
| *Ptilium crista-castrensis* | 1 | | | | | | 1 | | | | | | | | 1 | | | 1 |
| *Pylaisiella polyantha* | | | | | 1 | | | | | | | | | | 1 | | | |
| *Rhizomnium magnifolium** | | | | | | | | | | | | | | | | | | |
| *Rhizomnium pseudopunctatum* | | | | | | | | | | | | | | | | | | |
| *Rhytidiadelphus triquetrus* | | | | | | | | | | | | | | | | | | |
| *Rhytidium rugosum* | | | | | | | | | | | | | | | | | | |
| *Sanionia uncinata* | | | | | | | | | | | | | | | | | | |

Appendix 1 (continued)

| | 1.1 | 1.2 | 1.3 | 1.5 | 2.1 | 2.2 | 3.1 | 3.3 | 3.4 | 4.1 | 6.1 | 6.2 | 6.3 | 7.1 | 8.1 | 8.2 | 8.3 | 9.1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Sphagnum angustifolium* | | | | | | | | | | | | | | | | | | |
| *Sphagnum fuscum* | | | | | | | | | | 1 | | | | | | | | |
| *Sphagnum magellanicum* | | | | | | | | | | | | | | | | | | |
| *Sphagnum riparium* | | | | | | | | | | | | | | | | | | |
| *Sphagnum squarrosum* | | | | | | | | | | | | | | | | | | |
| *Splachnum ampullaceum** | | | | | | | | | | | | | | 1 | | | | |
| *Tetraphis pellucida* | | | | | | | | | | | | | | | | | | |
| *Thuidium recognitum* | | | | | 1 | | | | | | | | | | | | | |
| *Tomenthypnum falcifolium* | | | | | | | | | | | | | | | | | | |
| *Tomenthypnum nitens* | | | | | | | | | | 1 | | | | | | | | |
| *Tortella fragilis* | | | | | | | | | | | | | | | | | | |
| *Tortula mucronifolia* | | | | | | | | | | | | 1 | | | | | | |
| *Tortula ruralis* | | | | | | | | | | | | | | | | | | |
| *Warnstorfia exannulata* | | | | | | | | 1 | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
| **Liverworts** | | | | | | | | | | | | | | | | | | |
| *Mylia anomala* | | | | | | | | | | 1 | | | | | | | | |
| *Ptilidium pulcherrimum* | | | | | | | | | | | | | | | | | | 1 |
| | | | | | | | | | | | | | | | | | | |
| **Lichens** | | | | | | | | | | | | | | | | | | |
| *Cladina mitis* | 1 | | | | | | | | | | | | | | | | | 1 |
| *Cladonia coniocraea* | | | | | | | | | | | | | | | | | | |
| *Cladonia cornuta* | 1 | | | | | | | | | | | | | | | | | |
| *Cladonia crispata* | | | | | | | | | | | | | | | | 1 | | |
| *Cladonia gracilis* ssp. *turbinata* | 1 | | | | | | | | | | | | | | | | | |
| *Cladonia multiformis* | | | | | | 1 | | | | | | | | | | | | |
| *Evernia mesomorpha* | | | | | | | | | | | | | | | | | | |
| *Hypocenomyce friesii** | | | | | | | | | | | | | | | | | | |
| *Hypocenomyce scalaris* | | | | | | | | | | | | | | | | | | |
| *Leptogium saturninum* | | | | | | | 1 | | | | | | | | | | | |
| *Melanelia subaurifera* | | | | | | | | | | | | | | | | | | |
| *Parmelia sulcata* | | | | | | | | | | | | | | | | | | |
| *Peltigera canina* | | | | | | 1 | | | 1 | | | | | | | | | |
| *Peltigera elisabethae* | | | | | | | | | | | | | | | | | | |
| *Peltigera neopolydactyla* | | 1 | | | | | | | | | | | | | | | | |
| *Peltigera rufescens* | | | | | | | | | | | | | | | | | | |
| *Tuckermannopsis americana* | | | | | | | | | | | | | | | | | | 1 |
| *Vulpicida pinastri* | | | | | | | | | | | | | | | | | | |

Appendix 1 (continued)

| | 9.2 | 10.1 | 11.1 | 11.2 | 11.4 | 12.1 | 12.2 | 12.3 | 12.4 | 14.1 | 14.2 | 15.1 | 16.1 | 16.3 | 17.1 | 17.2 | 17.3 | 17.4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Mosses** | | | | | | | | | | | | | | | | | | |
| *Abietinella abietina* | | | | | | | | | | | | | | | | | | |
| *Aloina rigida** | | | | | | | | | | | | | | | | | | |
| *Amblystegium serpens* | | | | | | 1 | | 1 | 1 | | | 1 | | | | | | |
| *Atrichum selwynii* | | | | | | | 1 | | | | | | | | | | | |
| *Aulacomnium palustre* | | | | 1 | | | | | | | 1 | 1 | | | | | | 1 |
| *Barbula unguiculata* | | | | | | | | | | | | | | | | | | |
| *Brachythecium rivulare* | | | | | | | | 1 | 1 | | | | | | | | | |
| *Brachythecium rutabulum** | | | | | 1 | | | | | | | | | | | | | |
| *Brachythecium salebrosum* | | | | | | | | | | | | 1 | | | | | | |
| *Brachythecium starkei* | 1 | | | | | | | | | | | | | | | | | |
| *Brachythecium turgidum* | | | | | | | | | | | | | | | | | | |
| *Bryoerythrophyllum recurvirostre* | | | | | | | | | | | | | | | | | | |
| *Bryohaplocladium microphyllum* | | | | | | | | | | | | | | | | | | |
| *Bryum argenteum* | | | | | | 1 | 1 | | | | | | | | | | | |
| *Bryum capillare* | | | | | | 1 | | | | | | | | | | | | |
| *Bryum lisae* var. *cuspidatum* | 1 | | | | | | | | | | | | | | | | | |
| *Bryum pseudotriquetrum* | | | | | | | | | | | | | | | | | | |
| *Calliergon cordifolium* | | | | | | | | | 1 | | | | | | | | | |
| *Campylium hispidulum* | | | | | | | | | 1 | | | | | | | | | |
| *Ceratodon purpureus* | 1 | | | 1 | 1 | 1 | 1 | | | | | | 1 | 1 | | | | |
| *Climacium dendroides* | | | | | | | | | | | | | | | | | | |
| *Cratoneuron filicinum* | | | | | | | | | 1 | | | | | | | | | |
| *Dicranella heteromalla** | | | | | 1 | | | | | | | | | | | | | |
| *Dicranella subulata** | | | | 1 | | | | | | | | | | | | | | |
| *Dicranella varia* | | | | | | | | | | | | | | | | | | |
| *Dicranum flagellare* | 1 | | | | | | | | | | | 1 | | | | | | |
| *Dicranum fragilifolium* | 1 | | | | | | | | | 1 | | 1 | | | | | | |
| *Dicranum polysetum* | | 1 | | | 1 | | | | | | | | | | | | | |
| *Dicranum undulatum* | | | | | | | | | | | | | | | | | | |
| *Distichium capillaceum* | | | | | | | | | | | | | | | | | 1 | |
| *Drepanocladus aduncus* | | | | | | | | | | 1 | | | 1 | | | | | |
| *Eurhynchium pulchellum* | | 1 | | | | | | | | | | | | | | | | |
| *Funaria hygrometrica* | 1 | | | | | | | | 1 | | | | | | | | | |
| *Hygrohypnum molle** | | | | | | | | | 1 | | | | | | | | | |
| *Hygrohypnum ochraceum** | | | | | | | | | | 1 | 1 | 1 | 1 | | | | | |
| *Hylocomium splendens* | | | | | 1 | | | | | | | | | | | | | |

Appendix 1 (continued)

| | 9.2 | 10.1 | 11.1 | 11.2 | 11.4 | 12.1 | 12.2 | 12.3 | 12.4 | 14.1 | 14.2 | 15.1 | 16.1 | 16.3 | 17.1 | 17.2 | 17.3 | 17.4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Hypnum lindbergii* | | | | | | | | | | | | | | | | | | |
| *Hypnum pallescens** | | | 1 | | | | | | | | | | | | | | | |
| *Hypnum pratense* | | | | | | | | | | | | | | | | | | |
| *Isopterygiopsis pulchella* | | | | | | | | | | | | 1 | | | | | | |
| *Leptobryum pyriforme* | 1 | | | | | | | | | | | | | 1 | | | | |
| *Leptodictyum riparium* | | | | | | | | | | | | | | | | | | |
| *Limprichtia revolvens* | | | | | | | | | 1 | | | | | | | | | |
| *Myurella julacea* | | | | | | | | | | | | | | | | | | |
| *Neckera pennata** | | | | | | | | | | | | | | | | | | |
| *Onchophorus wahlenbergii* | | | | | | | | | | | | | | | | | | |
| *Oncophorus virens* var. *serrata* | | | | | | | | | 1 | | | | | | | | | |
| *Orthotrichum obtusifolium* | | | | | | | | | | | | 1 | | | | | | |
| *Orthotrichum speciosum* | | | | | | | | | | | | 1 | | | | | | |
| *Physcomitrium hookeri* | | | | | | | | | | | | | | | | | | |
| *Plagiomium cuspidatum* | | | | | | | | | | | | 1 | 1 | | | | | |
| *Plagiomnium ellipticum* | | | | | | | | | | | | | | | | | | |
| *Platygyrium repens* | | | | | | | | | | | | | | | | | | |
| *Playdictya jungermannioides* | | | | | | | | | | | | | | | | | | |
| *Pleurozium schreberi* | | | 1 | 1 | 1 | | | | | 1 | 1 | | | | | | | |
| *Pogonatum dentatum** | | | | | 1 | 1 | | | | | | | | | | | | |
| *Pohlia cruda* | 1 | | | | | 1 | 1 | | | | | 1 | | | | | | |
| *Pohlia nutans* | 1 | | | | 1 | | | | | | | | | | | | | |
| *Pohlia proligera* | | | | | | | 1 | | | | | | | | | | | |
| *Pohlia wahlenbergii* | | | | | | | | | 1 | | | | | | | | | |
| *Polytrichum commune* | | | 1 | | 1 | 1 | | | | | | | 1 | | | | | 1 |
| *Polytrichum juniperinum* | | | | 1 | 1 | 1 | 1 | | | | | | 1 | | | | | |
| *Polytrichum piliferum* | | | | | | 1 | | | | | | | | | | | | |
| *Polytrichum strictum* | | | | 1 | | | | | | | 1 | | | | | | | |
| *Ptilium crista-castrensis* | | | 1 | 1 | 1 | | | | | 1 | | 1 | 1 | | | | | |
| *Pylaisiella polyantha* | | 1 | | | | | | | 1 | 1 | | 1 | 1 | | | | | |
| *Rhizomnium magnifolium** | | | | | | | | | 1 | | | | | | | | | |
| *Rhizomnium pseudopunctatum* | | | | | | | | | 1 | | 1 | | | | | | | |
| *Rhytidiadelphus triquetrus* | | | | | | | | | | 1 | | | 1 | | | | | |
| *Rhytidium rugosum* | | | | | | | | | | | | | | | | | | |
| *Sanionia uncinata* | | | | | | | | | | 1 | | | 1 | | | | | |
| *Sphagnum angustifolium* | | | | | | | | | | | | | | | | 1 | | |
| *Sphagnum fuscum* | | | | | | | | | | | | | | | | | | |
| *Sphagnum magellanicum* | | | | | | | | | | | | | | | | | | |

Appendix 1 (continued)

| | 9.2 | 10.1 | 11.1 | 11.2 | 11.4 | 12.1 | 12.2 | 12.3 | 12.4 | 14.1 | 14.2 | 15.1 | 16.1 | 16.3 | 17.1 | 17.2 | 17.3 | 17.4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Sphagnum riparium* | | | | | | | | | | | | | | | 1 | | | |
| *Sphagnum squarrosum* | | | | | | | | | | | | | | | 1 | | | |
| *Splachnum ampullaceum** | | | | | | | | | | | | | | | | | | |
| *Tetraphis pellucida* | | | | | 1 | | | | | 1 | | | | | | | | |
| *Thuidium recognitum* | | | | | | | | | | 1 | 1 | 1 | 1 | | | | | |
| *Tomenthypnum falcifolium* | | | | | | | | | | | | | | | | | 1 | |
| *Tomenthypnum nitens* | | | | | | | | | | | | | | | | | | |
| *Tortella fragilis* | | | | | | | | | | | | | | | | | | |
| *Tortula mucronifolia* | | | | | | | | | | | | | | | | | | |
| *Tortula ruralis* | | | | | | | | | | | | | | | | | | |
| *Warnstorfia exannulata* | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
| **Liverworts** | | | | | | | | | | | | | | | | | | |
| *Mylia anomala* | | | | | | | | | | | | | | | | | | |
| *Ptilidium pulcherrimum* | | | 1 | | 1 | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
| **Lichens** | | | | | | | | | | | | | | | | | | |
| *Cladina mitis* | | | | | | | | | | | | | | | | | | |
| *Cladonia coniocraea* | | | 1 | | | | | | | | | | | | | | | |
| *Cladonia cornuta* | | | | | | | | | | | | | | | | | | |
| *Cladonia crispata* | | | | | | | | | | | | | | | | | | |
| *Cladonia gracilis* ssp. *turbinata* | | | | | | | | | | | | | | | | | | |
| *Cladonia multiformis* | | | | | | | | | | | | | | | | | | |
| *Evernia mesomorpha* | | 1 | | | | | | | | | | | | | | | | |
| *Hypocenomyce friesii** | 1 | | 1 | | | | | | | | | | | | | | | |
| *Hypocenomyce scalaris* | 1 | | | | | | | | | | | | | | | | | |
| *Leptogium saturnimum* | | | | | | | | | | | | | | | | | | |
| *Melanelia subaurifera* | | 1 | | | | | | | | | | | | | | | | |
| *Parmelia sulcata* | | 1 | 1 | | | | | | | | | | | | | | | |
| *Peltigera canina* | | | | | | | | | | | | | | | | | | |
| *Peltigera elisabethae* | | | | | | | | | | | | | | | | | | |
| *Peltigera neopolydactyla* | | | | | | | | | | | | | | | | | | |
| *Peltigera rufescens* | | | | | | | 1 | | | | | | | | | | | |
| *Tuckermannopsis americana* | | | 1 | | | | | | | | | | | | | | | |
| *Vulpicida pinastri* | | | 1 | | | | | | | | | | | | | | | |

Appendix 1 (continued)

| | 17.5 | 18.1 | 23.1 | 34.1 | 34.2 | 34.3 | 35.1 | 35.2 | 36.1 | 36.2 | 37.1 | 38.1 | 39.1 | 43.1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Mosses** | | | | | | | | | | | | | | |
| *Abietinella abietina* | | | | | 1 | | | | | | 1 | | | |
| *Aloina rigida** | | | | | | | | | | | | | | 1 |
| *Amblystegium serpens* | | | | | | 1 | | | | | | | | |
| *Atrichum selwynii* | | | | | | | | | | | | | | |
| *Aulacomnium palustre* | | 1 | 1 | | | | | | 1 | | | | 1 | |
| *Barbula unguiculata* | | | | | | | | | | | | | | |
| *Brachythecium rivulare* | | | | | | | | | | | | | | |
| *Brachythecium rutabulum** | | | | | | | | | | | | | | |
| *Brachythecium salebrosum* | | | | | | | | | | | | 1 | | |
| *Brachythecium starkei* | | | | | | | | | | | | | | |
| *Brachythecium turgidum* | | | | | | | | | | | | | | |
| *Bryoerythrophyllum recurvirostre* | | | | | | | | | | | | | | |
| *Bryohaplocladium microphyllum* | | | | | | 1 | | | | | | | | |
| *Bryum argenteum* | | | | | | | | | | | 1 | | | |
| *Bryum capillare* | | | | | | | | | | | | | | |
| *Bryum lisae* var. *cuspidatum* | | | | | | | | | | | | | | |
| *Bryum pseudotriquetrum* | | | | | | | | | | | | | 1 | |
| *Calliergon cordifolium* | | | | | | | | | | | | | | |
| *Campylium hispidulum* | | | | | | | | | | | | | | |
| *Ceratodon purpureus* | | | | | | | | | | | 1 | | 1 | |
| *Climacium dendroides* | | | | | | | | | | | | | | |
| *Cratoneuron filicinum* | | | | | | | | | | | | | | |
| *Dicranella heteromalla** | | | | | | | | | | | | | | |
| *Dicranella subulata** | | | | | | | | | | | | | | |
| *Dicranella varia* | | | | | | | | 1 | | | | | | |
| *Dicranum flagellare* | | | | | | | | 1 | | | | 1 | | |
| *Dicranum fragilifolium* | | | | | | | | | | | | | | |
| *Dicranum polysetum* | | | | | | | | 1 | | | | | | |
| *Dicranum undulatum* | | | | | | | 1 | | | | | | | |
| *Distichium capillaceum* | | | | | 1 | | | | | | 1 | | | |
| *Drepanocladus aduncus* | | | | | | | | | | | | | | |
| *Eurhynchium pulchellum* | | | | | | 1 | | | | | | | | |
| *Funaria hygrometrica* | | | | | | | 1 | | | | | | 1 | |
| *Hygrohypnum molle** | | | | | | | | | | | | | | |
| *Hygrohypnum ochraceum** | | | | | | | | | | | | | | |
| *Hylocomium splendens* | | | | 1 | | 1 | | | | 1 | | | | |

Appendix 1 (continued)

| | 17.5 | 18.1 | 23.1 | 34.1 | 34.2 | 34.3 | 35.1 | 35.2 | 36.1 | 36.2 | 37.1 | 38.1 | 39.1 | 43.1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Hypnum lindbergii* | | | | | | | | | | | | | | |
| *Hypnum pallescens** | | | | | | | | | | | | | | |
| *Hypnum pratense* | | | | | | | | | | | | | | |
| *Isopterygiopsis pulchella* | | | | | | | | | | | | | 1 | |
| *Leptobryum pyriforme* | | | | | | | | | | | | | | |
| *Leptodictyum riparium* | | | | | | | | | | | | | | |
| *Limprichtia revolvens* | | | | | | | | | | | | | | |
| *Myurella julacea* | | | | | | | | | | | | 1 | | |
| *Neckera pennata** | | | | | | | | | | | | | | |
| *Onchophorus wahlenbergii* | | | | | | | | | | | | | | |
| *Oncophorus virens* var. *serrata* | | | | | | 1 | | | | | | 1 | | |
| *Orthotrichum obtusifolium* | | | | | | 1 | | | | | | | | |
| *Orthotrichum speciosum* | | | | | | | | | | | | | | |
| *Physcomitrium hookeri* | | | | | | | | | | | | 1 | | |
| *Plagiomium cuspidatum* | | | | | | | | | 1 | | | | | |
| *Plagiomnium ellipticum* | | | | 1 | | 1 | | | | | | | | |
| *Platygyrium repens* | | | | | | | | | | | | | | |
| *Playdictya jungermannioides* | | 1 | | 1 | | | 1 | 1 | | 1 | | | | |
| *Pleurozium schreberi* | | | | | | | | | | | | | | |
| *Pogonatum dentatum** | | | | | | | | | | | | | | |
| *Pohlia cruda* | | | | | | | | | | | | | | |
| *Pohlia nutans* | | | | | | | | | | | | | | |
| *Pohlia proligera* | | | | | | | | | | | | | | |
| *Pohlia wahlenbergii* | | | | | | | | | | | | | | |
| *Polytrichum commune* | | | | | | | | | | | 1 | | 1 | |
| *Polytrichum juniperinum* | | | | | | | | | | | | | | |
| *Polytrichum piliferum* | | | | | | | 1 | | 1 | | | | | |
| *Polytrichum strictum* | | | | 1 | | | | | | 1 | | | | |
| *Ptilium crista-castrensis* | | | | | | 1 | | | | | | 1 | | |
| *Pylaisiella polyantha* | | | | | | | | | | | | | | |
| *Rhizomnium magnifolium** | | | | | | | | | | | | | | |
| *Rhizomnium pseudopunctatum* | | | | | | | | | | | | | | |
| *Rhytidiadelphus triquetrus* | | | | | | | | | | | 1 | | | |
| *Rhytidium rugosum* | | | | | 1 | | | | | | | | | |
| *Sanionia uncinata* | | | | | | | | | | | | | | |
| *Sphagnum angustifolium* | | | | | | | | | | | | | | |
| *Sphagnum fuscum* | | | | | | | 1 | | | | | | | |
| *Sphagnum magellanicum* | | | | | | | 1 | | | | | | | |

Appendix 1 (continued)

| | 17.5 | 18.1 | 23.1 | 34.1 | 34.2 | 34.3 | 35.1 | 35.2 | 36.1 | 36.2 | 37.1 | 38.1 | 39.1 | 43.1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Sphagnum riparium* | | | | | | | | | | | | | | |
| *Sphagnum squarrosum* | | | | | | | 1 | | | | | | | |
| *Splachnum ampullaceum** | 1 | | | | | | | | | | | | | |
| *Tetraphis pellucida* | | | | | | 1 | | | | | | | | |
| *Thuidium recognitum* | | | | | | | | | | | | | | |
| *Tomenthypnum falcifolium* | | | | | | | | | | | | | | |
| *Tomenthypnum nitens* | | | 1 | | | | | | 1 | | | | 1 | |
| *Tortella fragilis* | | | | | | | | | | | 1 | | | |
| *Tortula mucronifolia* | | | | | | 1 | | | | | 1 | | | |
| *Tortula ruralis* | | | | | 1 | | | | | | 1 | | | |
| *Warnstorfia exannulata* | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| **Liverworts** | | | | | | | | | | | | | | |
| *Mylia anomala* | | | | | | | | | | | | | | |
| *Ptilidium pulcherrimum* | | | | | | | | 1 | | | | | | |
| | | | | | | | | | | | | | | |
| **Lichens** | | | | | | | | | | | | | | |
| *Cladina mitis* | | | | | | | | | | | | | | |
| *Cladonia coniocraea* | | | | | | | | | | | | | | |
| *Cladonia cornuta* | | | | | | | | | | | | | | |
| *Cladonia crispata* | | | | | | | | | | | | | | |
| *Cladonia gracilis* ssp. *turbinata* | | | | | | | | | | | | | | |
| *Cladonia multiformis* | | | | | | | | | | | | | | |
| *Evernia mesomorpha* | | | | | | | | | | | | | | |
| *Hypocenomyce friesii** | | | | | | | | | | | | | | |
| *Hypocenomyce scalaris* | | | | | | | | | | 1 | | | | |
| *Leptogium saturninum* | | | | | | | | | | | | | | |
| *Melanelia subaurifera* | | | | | | | | | | | | | | |
| *Parmelia sulcata* | | | | | | | | | | | | 1 | | |
| *Peltigera canina* | | | | | | | | | | | | | | |
| *Peltigera elisabethae* | | | | | | 1 | | | | | | | | |
| *Peltigera neopolydactyla* | | | | | | | | | | | | | | |
| *Peltigera rufescens* | | | | | | | | | | | 1 | | | |
| *Tuckermannopsis americana* | | | | | | | | | | | | | | |
| *Vulpicida pinastri* | | | | | | | | | | | | | | |

**Appendix 2.** Vascular plants recorded during the rare plant survey in the Whitecourt study area.
(Numbers across the top of the table correspond to site numbers used for this study).

| | 1.1 | 1.2 | 1.3 | 1.4 | 2.1 | 3.1 | 3.2 | 3.4 | 4.1 | 4.2 | 4.3 | 5.1 | 6.1 | 6.2 | 6.3 | 6.4 | 7.1 | 8.1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Achillea millefolium* | 1 | 1 | | | | 1 | | | 1 | | | | | | | | 1 | 1 |
| *Achillea sibrica* | | | | | | | | | | | | | | | | | | |
| *Actaea rubra* | | | | | | 1 | | | | 1 | | | | 1 | 1 | | | |
| *Agropyron trachycaulum* | | | | | | | | | | | | | | | | | | |
| *Agropyron trachycaulum unilaterale* | | | | | | | | | | | | | | | | | | |
| *Agrostis scabra* | | | | | | | | | | | | | | | | | | |
| *Amelanchier alnicola* | | | | | | | | | | | 1 | | | 1 | 1 | 1 | | |
| *Andromeda polifolia* | | | | | | | | 1 | | | | 1 | | | | | | |
| *Apocynum androsaemifolium* | | | | | | | | | | | | | | | | 1 | | |
| *Aralia nudicaulis* | | | | | | 1 | | | | | 1 | | | 1 | | 1 | | |
| *Arctostaphylos uva-ursi* | | | | | | | | | | | | | | | | | | |
| *Arnica cordifolia* | | | | | | 1 | | | | | | | | 1 | | | | |
| *Aster conspicuous* | | | | | | | | | | 1 | | | | | | | | |
| *Aster ciliolatus* | | | | | | 1 | | | 1 | 1 | 1 | | | 1 | 1 | 1 | 1 | |
| *Aster puniceus* | | | | | | | | | | | | | | 1 | 1 | | | |
| *Astragalus canadensis* | | | | | | | | | | | | | | 1 | 1 | | | |
| *Athyrium filix-feminia* | | | | | | | | | | | | | | | | | | 1 |
| *Betula glandulosa* | | | | | | | 1 | 1 | | | | | | | | | | |
| *Botrychium virginianum* | | | | | | | | | | | | | | | | | | |
| *Bromus ciliatus* | | | | | | | | | 1 | | 1 | | | 1 | 1 | 1 | 1 | |
| *Bromus inermis* | | | | | | | | | | | | | | | 1 | | | |
| *Calamagrostis canadensis* | 1 | | | | | 1 | 1 | | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | |
| *Calamagrostis inexpansa* | | | | | | | | 1 | | | | 1 | | | | | | |
| *Callitriche verna* | | | | 1 | | | | | | | | | | | | | | |
| *Caltha palustris* | | | | | | | | 1 | | | | | | | | | | |
| *Campanula rotundifolia* | | | | | | | | | | | | | | | | | | |
| *Carex aquatilis* | | | | 1 | 1 | | 1 | 1 | | | | | | | | | | |
| *Carex atherodes* | | | | | | | 1 | 1 | | | | | 1 | 1 | 1 | | | |
| *Carex disperma* | | | | | | | | | | | | | | | | | | |
| *Carex siccata* | | | | | | | | | | | | | | | | | | |
| *Carex tenuifolia* | | | | | | | | 1 | | | | 1 | | | | | | |
| *Castilleja miniata* | | | | | | | | | | | | | | | | 1 | | |
| *Ceratophyllum demersum* | | | | | | | | | | | | | | | | | | |
| *Chrysanthemem leucanthemum* | | | | | | | | | | | | | | | | | | |
| *Chrysosplenium tetrandrum* | | | | | | | | | | | | | | | | | | 1 |

Appendix 2 (continued)

| | 1.1 | 1.2 | 1.3 | 1.4 | 2.1 | 3.1 | 3.2 | 3.4 | 4.1 | 4.2 | 4.3 | 5.1 | 6.1 | 6.2 | 6.3 | 6.4 | 7.1 | 8.1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Cinna latifolia* | | | | | | | | | | | | | | | | | | |
| *Cornus canadensis* | 1 | | | | | 1 | | | 1 | 1 | | | | 1 | 1 | | 1 | 1 |
| *Cornus stolonifera* | | | | | | 1 | | | | | | | | | | | | |
| *Cypripedium passerinum* | | | | | | | | | | | | | | | | | | |
| *Delphinium glaucum* | 1 | | | | | | | | | | | | | 1 | 1 | | | 1 |
| *Deschampsia caespitosa* | 1 | | | | | | | | | | | | | | | | | 1 |
| *Dryopteris carthusiana* | | | | | | | | | | | | | | | | | | |
| *Elymus glaucus* | | | | | | | | | 1 | | | | | 1 | 1 | | 1 | |
| *Elymus innovatus* | | | | | | | | | | 1 | | | | | | | | |
| *Epilobium angustifolium* | 1 | | 1 | | | 1 | | | 1 | 1 | | | | 1 | 1 | | 1 | 1 |
| *Epilobium ciliatum* | | | | | | | | | | | | | | | | | | |
| *Equisetum arvense* | 1 | | | | | 1 | | | 1 | | | | | 1 | | | 1 | 1 |
| *Equisetum scirpoides* | | | | | | | | | 1 | | | | 1 | | | | 1 | |
| *Equisetum sylvaticum* | | | | | | | | | | | | | | 1 | 1 | | | |
| *Fragaria vesca* | | | | | | | | | | 1 | | | | | | | | |
| *Fragaria virginiana* | 1 | | | | | 1 | | | 1 | 1 | 1 | | | 1 | 1 | 1 | 1 | 1 |
| *Galium boreale* | 1 | | | | | 1 | 1 | 1 | 1 | 1 | | | | 1 | 1 | | 1 | 1 |
| *Galium trifidum* | | | | | | | | | | | | | | | | | | |
| *Galium trifolium* | | | | | | 1 | | | | | | | | 1 | | | | |
| *Geocaulon lividum* | | | | | | | | | | | | | | | | | | |
| *Geum aleppicum* | | | | | | | | | | | | | | | | | | |
| *Geum macrophyllum* | | | | | | | | | | | | | | | | | | |
| *Gymnocarpium dryopteris* | | | | | | | | | | | | | | 1 | | | | 1 |
| *Habenaria viridis* | | | | | | | | | 1 | | | | | | | | 1 | |
| *Heracleum lanatum* | | | | | | | | | | | | | | 1 | 1 | | | |
| *Hieracium umbellatum* | 1 | | | | | 1 | | | | 1 | | | 1 | | | | | 1 |
| *Hierochloe odorata* | | | | | | | | | | | | | | | | | | |
| *Hordeum jubatum* | | | | | | | | | | | | | | | | | | |
| *Impatiens capensis* | | | | | | | | | | | | | | | | | | 1 |
| *Juncus balticus* | | | | | | | | | | | | | 1 | | | | | |
| *Juncus nodosus* | | | | | | | | | 1 | | | | | | | | 1 | |
| *Juncus tenuis* | | | | | | | | | | | | | | 1 | 1 | | | |
| *Kalmia microphylla* | | | | | | | | | 1 | | | | | | | | 1 | |
| *Lathyrus ochroleucus* | 1 | 1 | | | | 1 | | | | 1 | 1 | | | | | 1 | | 1 |
| *Ledum groenlandicum* | | | 1 | | | | | 1 | 1 | 1 | | | | | | | 1 | |

Appendix 2 (continued)

| | 1.1 | 1.2 | 1.3 | 1.4 | 2.1 | 3.1 | 3.2 | 3.4 | 4.1 | 4.2 | 4.3 | 5.1 | 6.1 | 6.2 | 6.3 | 6.4 | 7.1 | 8.1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Lemna minor* | | | | | | | | | | | | | | | | | | |
| *Limaea borealis* | | | 1 | | | 1 | | | 1 | 1 | | | | 1 | 1 | | 1 | |
| *Lonicera dioca* | | | | | | | | | | | | | | | | | | |
| *Lonicera involucrata* | 1 | | 1 | | | 1 | | | | 1 | | | | 1 | 1 | | | 1 |
| *Luzula parviflora* | | | | | | | | | | | | | | | | | | |
| *Lycopodium annotinum* | | | | | | | | | | | | | | | | | | |
| *Maianthemum canadense* | | | | | | 1 | | | | 1 | | | | | | | | |
| *Matteuccia struthiopteris* | | | | | | | | | | | | | | | | | | |
| *Melilotus officinalis* | | | | 1 | | | | | | | | | 1 | | | | | |
| *Menyanthes trifoliata* | | | | | | | | | | | | | | | | | | |
| *Mertensia paniculata* | 1 | 1 | | | | 1 | | | 1 | 1 | 1 | | | 1 | 1 | 1 | 1 | 1 |
| *Mitella nuda* | 1 | 1 | | | | 1 | | 1 | 1 | | | | | 1 | 1 | | 1 | 1 |
| *Moneses uniflora* | 1 | | | | | | | | | | | | | | | | | |
| *Myriophyllum exalbescens* | | | | | | | | | | | | | | | | | | |
| *Nuphar variegatum* | | | | | 1 | | | | | | | | | | | | | |
| *Oplopanax horridum* | | | | | | | | | | | | | | | | | | |
| *Orchis rotundifolia* | | | | | | | | | 1 | | | | | | | | | |
| *Oxycoccus microcarpus* | | | | | | | | 1 | | | | 1 | | | | | | |
| *Parnassia palustris* | | | | | | | | | 1 | | | | | | | | 1 | |
| *Petasites palmatus* | 1 | 1 | | | | 1 | | 1 | 1 | 1 | 1 | | | 1 | 1 | 1 | 1 | 1 |
| *Petasites sagittatus* | | | 1 | | | | 1 | 1 | | | | | | | | | | 1 |
| *Phleum pratense* | 1 | 1 | | | | | | | | | | | | 1 | 1 | | | |
| *Polygonum amphibium* | | | | | | | | | | | | | | | | | | |
| *Polygonum lapathifolium* | | | | | | | | | | | | | | | | | | |
| *Potamogeton natans* | | | | | | | | | | | | | | | | | | |
| *Potamogeton gramineus* | | | | | | | | | | | | | | | | | | |
| *Potamogeton richardsonii* | | | | | 1 | | | | | | | | | | | | | |
| *Potentilla arguta* | | | | | | | | | | | | | | | | | | |
| *Potentilla gracilis* | | | | | | | | | | | | | | | | | | |
| *Potentilla palustris* | | | | | | | 1 | 1 | | | | 1 | | | | | | |
| *Pyrola asarifolia* | | | | | | 1 | | | | 1 | 1 | | | | | 1 | | |
| *Pyrola secunda* | | | | | | | | | | 1 | | | | | | | | |
| *Ranunculus acris* | 1 | | | | | | | | | | | | | | | | | 1 |
| *Ribes americanum* | | | | | | | | | | | | | | | | | | |
| *Ribes lacustre* | | | | | | | | | 1 | | | | | | | | 1 | |
| *Ribes oxyacanthoides* | | | | | | 1 | | | 1 | | | | | 1 | 1 | | 1 | |

Appendix 2 (continued)

| | 1.1 | 1.2 | 1.3 | 1.4 | 2.1 | 3.1 | 3.2 | 3.4 | 4.1 | 4.2 | 4.3 | 5.1 | 6.1 | 6.2 | 6.3 | 6.4 | 7.1 | 8.1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Ribes triste* | | | | | | 1 | | | | | | | | | | | | |
| *Rosa acicularis* | 1 | 1 | 1 | | | 1 | | | 1 | 1 | 1 | | | 1 | 1 | 1 | 1 | 1 |
| *Rubus chamaemorus* | | | 1 | | | | | | | | | | | | | | | |
| *Rubus idaeus* | | | | | | 1 | | | | | 1 | | | 1 | | 1 | | 1 |
| *Rubus pedatus* | | | | | | | | | | | | | | | | | | |
| *Rubus pubescens* | | | | | | 1 | | | 1 | 1 | | | | 1 | 1 | | 1 | |
| *Rumex triangulivalvis* | | | | | | | | 1 | | | | 1 | | | | | | |
| *Sagittaria cuneata* | | | | | | | | | | | | | | | | | | |
| *Sambucus racemosa* | | | | | | | | | | | | | | | | | | |
| *Sanicula marilandica* | | | | | | | | | | | | | | | | | | |
| *Schizachne purpurascens* | | | | | | | | | | 1 | | | | | | | | |
| *Scirpus validus* | | | | | | | | | | | | | | | | | | |
| *Scutellaria galericulata* | | | | | | | | | | | | | | | | | | |
| *Shepherdia canadensis* | | | | | | | | 1 | | 1 | | | | | | | | |
| *Smilacina stellata* | | | | | | | | | | | | | | | | | | |
| *Smilacina trifoliata* | | | | | | | | | 1 | | | | | | | | 1 | |
| *Solidago canadensis* | | | | | | | | | 1 | | 1 | | | | | 1 | 1 | |
| *Sonchus arvensis* | | | | | | | | 1 | | | | | 1 | 1 | | | | |
| *Sorbus scopulina* | | | | | | | | | | | | | | | | | | |
| *Sparganium angustifolium* | | | | | | | | | | | | | | | | | | |
| *Sparganium eurycarpum* | | | | | | | | | | | | | | | | | | |
| *Stellaria calycantha* | 1 | | | | 1 | | 1 | 1 | | | | | | | | | | 1 |
| *Stellaria longifolia* | | | | | | | 1 | 1 | | | | | | | | | | 1 |
| *Symphoricarpos albus* | | | | | | 1 | | | | 1 | 1 | | | | 1 | 1 | | |
| *Taraxacum officinale* | 1 | 1 | | | | | | | | | 1 | | | 1 | | 1 | | 1 |
| *Thalictrum vemulosum* | | | | | | 1 | | | | | | | | 1 | 1 | | | |
| *Trientalis borealis* | | | | | | | | | | | | | | 1 | 1 | | | |
| *Trifolium hybridum* | 1 | | | | | | | | | | | | | | | | | 1 |
| *Typha latifolia* | | | | | | | | | | | | | | | | | | |
| *Urtica dioica* | | | | | 1 | | | | | | | | | | | | | |
| *Vaccinium caespitosum* | | | | | | | | | | 1 | | | | | | | | |
| *Vaccinium myrtilloides* | | 1 | | | | | | | | | | | | | | | | |
| *Veronica americana* | | | | | | | | | | | | | | | | | | |
| *Viburnum edule* | | | | | | 1 | | | | 1 | 1 | | | 1 | | 1 | | |
| *Vicia americana* | | | | | | 1 | | | | 1 | 1 | | | | | 1 | | |
| *Viola candensis* | | | | | | | | | | 1 | | | | | | | | |
| *Viola renifolia* | 1 | | | | | 1 | | | | 1 | | | | 1 | 1 | | | 1 |

Appendix 2 (continued)

| | 8.2 | 8.3 | 9.1 | 9.2 | 10.1 | 11.1 | 11.3 | 11.4 | 12.2 | 12.5 | 14.1 | 14.2 | 16.1 | 17.1 | 17.4 | 18.1 | 19.1 | 20.1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Achillea millefolium* | | | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| *Achillea sibrica* | | | | | | | | | 1 | | | | | | | | | |
| *Actaea rubra* | | 1 | | | | | | | 1 | 1 | 1 | | 1 | | 1 | | | |
| *Agropyron trachycaulum* | | | | | | | | | | | | | | | | | | |
| *Agropyron trachycaulum unilaterale* | | | | | | | | | | | | | | | | | | |
| *Agrostis scabra* | | | | | | | | | | | | | | | | | | |
| *Amelanchier alnicola* | | 1 | | | 1 | | | | | 1 | | | | | | | | |
| *Andromeda polifolia* | 1 | | | | | | | | | | | | | | | | | |
| *Apocynum androsaemifolium* | | | | | | | | | | | | | | | | | | |
| *Aralia nudicaulis* | | | | | 1 | 1 | | | 1 | 1 | 1 | | 1 | | 1 | | | |
| *Arctostaphylos uva-ursi* | | | 1 | 1 | | | | 1 | | | | | | | | 1 | 1 | |
| *Arnica cordifolia* | | | | | | 1 | | | | | 1 | | 1 | | 1 | | | |
| *Aster conspicuous* | | | | | | | | | 1 | 1 | | | | | | | | |
| *Aster ciliolatus* | | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | |
| *Aster puniceus* | | 1 | | 1 | | | | 1 | 1 | 1 | | | | | | | 1 | |
| *Astragalus canadensis* | | 1 | | | | | | | 1 | 1 | | | | | | | | |
| *Athyrium filix-feminia* | | | | | | 1 | | | | | | | | | | | | |
| *Betula glandulosa* | | | | | | | | | | | | | | | | | | |
| *Botrychium virginianum* | | 1 | | | | | | | | | | | | | | | | |
| *Bromus ciliatus* | | 1 | | | 1 | | | | | 1 | | 1 | | 1 | | | | 1 |
| *Bromus inermis* | | 1 | | | | | | | | | | | | | | | | |
| *Calamagrostis canadensis* | | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| *Calamagrostis inexpansa* | 1 | | | | | | | | | | | | | | | | | |
| *Callitriche verna* | | | | | | | | | | | | | | | | | | |
| *Caltha palustris* | | | | | | | | | | | | | | | | | | |
| *Campanula rotundifolia* | | | | | | 1 | | | | | | | | | | | | |
| *Carex aquatilis* | | | | | | | | | | | | | | | | | | |
| *Carex atherodes* | | 1 | | | | | | | 1 | | | | | | | | | |
| *Carex disperma* | | | 1 | | | | | 1 | | | | | | | | 1 | 1 | |
| *Carex siccata* | | 1 | | | | | | 1 | | | | | | | | | 1 | |
| *Carex temifolia* | 1 | | | | | | | | | | | | | | | | | 1 |
| *Castilleja miniata* | | | | | | | | | | | | | | | | | | |
| *Ceratophyllum demersum* | | | | | | | | | | | | | | | | | | |
| *Chrysanthemem leucanthemum* | | | | | | | | | 1 | | | | | | | | | |

Appendix 2 (continued)

| | 8.2 | 8.3 | 9.1 | 9.2 | 10.1 | 11.1 | 11.3 | 11.4 | 12.2 | 12.5 | 14.1 | 14.2 | 16.1 | 17.1 | 17.4 | 18.1 | 19.1 | 20.1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Chrysosplenium tetrandrum* | | | | | | | | | | | | | | | | | | |
| *Cinna latifolia* | | | | | | | | | | | | | | | | | | |
| *Cornus canadensis* | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | | 1 | |
| *Cornus stolonifera* | | | | | | | | 1 | | | 1 | | 1 | | 1 | | | |
| *Cypripedium passerinum* | 1 | | | | | | | | | | | | | | | | | |
| *Delphinium glaucum* | | 1 | | | | | 1 | | 1 | | | | | | | | | |
| *Deschampsia caespitosa* | | | | | | | 1 | | | | | | | | | | | |
| *Dryopteris carthusiana* | | | 1 | 1 | | 1 | 1 | 1 | 1 | | | | | | | | 1 | |
| *Elymus glaucus* | | 1 | | | | | | | | | | 1 | | 1 | | | | |
| *Elymus innovatus* | | | | | | | | | | | | | | | | | | |
| *Epilobium angustifolium* | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| *Epilobium ciliatum* | | | | | | | | | 1 | | | | | | | | | |
| *Equisetum arvense* | | 1 | | | | | 1 | | | | 1 | 1 | 1 | 1 | 1 | | | 1 |
| *Equisetum scirpoides* | | | | | | | | | | | | 1 | | 1 | | | | |
| *Equisetum sylvaticum* | | 1 | 1 | 1 | | 1 | | 1 | 1 | | | | | | | 1 | 1 | |
| *Fragaria vesca* | | | | | | | | | | | | | | | | | | |
| *Fragaria virginiana* | | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | |
| *Galium boreale* | | 1 | | | | 1 | 1 | | 1 | | 1 | 1 | 1 | 1 | 1 | | | |
| *Galium trifidum* | | | 1 | 1 | | | | 1 | | | 1 | | 1 | | 1 | | 1 | |
| *Galium trifolium* | | | | | | | | | | | 1 | | 1 | | 1 | | | |
| *Geocaulon lividum* | | | | | | | | | | | | | | | | | | |
| *Geum aleppicum* | | | 1 | 1 | | | | 1 | 1 | | | | | | | | 1 | |
| *Geum macrophyllum* | | | | | | | | | | 1 | | | | | | | | |
| *Gymnocarpium dryopteris* | | 1 | | | | 1 | | 1 | | | | | | | | | 1 | |
| *Habenaria viridis* | | | | | | | | | | | | 1 | | 1 | | | | |
| *Heracleum lanatum* | | 1 | | | | | | | 1 | | | | | | | | | |
| *Hieracium umbellatum* | | | 1 | 1 | | | 1 | 1 | 1 | | 1 | | 1 | | 1 | 1 | 1 | |
| *Hierochloe odorata* | | | 1 | 1 | | | | 1 | 1 | | | | | | | | 1 | |
| *Hordeum jubatum* | | | | | | | | | | | | | | | | | | |
| *Impatiens capensis* | | | | | | 1 | | | | 1 | | | | | | | | |
| *Juncus balticus* | | | | | | | | | | | | | | | | | | |
| *Juncus nodosus* | | | 1 | 1 | | | | 1 | 1 | | | 1 | | 1 | | | 1 | 1 |
| *Juncus tenuis* | | 1 | | | | | | | | | | | | | | | | |
| *Kalmia microphylla* | | | | | | | | | | | | 1 | | 1 | | | | |
| *Lathyrus ochroleucus* | | | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | | 1 | | 1 | | 1 | |

Appendix 2 (continued)

| | 8.2 | 8.3 | 9.1 | 9.2 | 10.1 | 11.1 | 11.3 | 11.4 | 12.2 | 12.5 | 14.1 | 14.2 | 16.1 | 17.1 | 17.4 | 18.1 | 19.1 | 20.1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Ledum groenlandicum* | | | 1 | 1 | | | | 1 | 1 | | | 1 | | 1 | | 1 | 1 | 1 |
| *Lemna minor* | | | | | | | | | | | | | | | | | | |
| *Linnaea borealis* | | 1 | | | | | | | | | 1 | 1 | 1 | 1 | 1 | | | |
| *Lonicera dioca* | | | | | | | | | | | | | | | | | | |
| *Lonicera involucrata* | | 1 | | 1 | | 1 | 1 | | | | 1 | | 1 | | 1 | | | |
| *Luzula parviflora* | | | | | | | | | | | | | | | | | | |
| *Lycopodium annotinum* | | | 1 | 1 | | | | 1 | 1 | | | | | | | | 1 | |
| *Maianthemum canadense* | | 1 | 1 | 1 | | | | 1 | 1 | | 1 | | 1 | | 1 | | 1 | |
| *Matteuccia struthiopteris* | | | | | | 1 | 1 | | | | | | | | | | | |
| *Melilotus officinalis* | | | | | | | | | | | | | | | | | | |
| *Menyanthes trifoliata* | | | | | | | | | | | | | | 1 | | | | |
| *Mertensia paniculata* | | 1 | | | 1 | | 1 | | | 1 | 1 | 1 | 1 | 1 | 1 | | | |
| *Mitella nuda* | | 1 | | 1 | | | 1 | | | | 1 | 1 | 1 | 1 | 1 | | | |
| *Moneses uniflora* | | | 1 | | | | | | | | | | | | | | | |
| *Myriophyllum exalbescens* | | | | | | | | | | | | | | | | | | |
| *Nuphar variegatum* | | | | | | | | | | | | | | | | | | |
| *Oplopanax horridum* | | | | | | 1 | 1 | 1 | | | | | | | | | | |
| *Orchis rotundifolia* | | | | | | | | | | | | | | | | | | |
| *Oxycoccus microcarpus* | 1 | | | | | | | | | | | | | | | | | 1 |
| *Parnassia palustris* | | | | | | | | | | | | 1 | | | | | | 1 |
| *Petasites palmatus* | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | |
| *Petasites sagittatus* | | | | | | 1 | | | | | | | | 1 | | | | |
| *Phleum pratense* | | 1 | 1 | | | | 1 | 1 | 1 | | | | | | | | 1 | |
| *Polygonum amphibium* | | | | | | | | | | | | | | | | | | |
| *Polygonum lapathifolium* | | | | | | | | | | | | | | | | | | |
| *Potamogeton natans* | | | | | | | | | | | | | | | | | | |
| *Potamogeton gramineus* | | | | | | | | | | | | | | | | | | |
| *Potamogeton richardsonii* | | | | | | | | | | | | | 1 | | | | | |
| *Potentilla arguta* | | | | | | | | | | | | | | | | | | |
| *Potentilla gracilis* | | | | | | | | | | | | | 1 | | | | | |
| *Potentilla palustris* | 1 | | | | | | | | | | | | | 1 | | | | |
| *Pyrola asarifolia* | | 1 | | | 1 | 1 | | | | 1 | 1 | | 1 | | 1 | | | |
| *Pyrola secunda* | | 1 | | | | | | | | | 1 | | 1 | | 1 | | | |
| *Ranunculus acris* | | | | | | | 1 | | | | | | | | | | | |
| *Ribes americanum* | | | | | | | | | | | | | | | | | | |
| *Ribes lacustre* | | | | | | | | | | | | | | 1 | | | | |
| *Ribes oxyacanthoides* | | 1 | | | | 1 | | | | | 1 | 1 | 1 | 1 | 1 | | | |

Appendix 2 (continued)

| | 8.2 | 8.3 | 9.1 | 9.2 | 10.1 | 11.1 | 11.3 | 11.4 | 12.2 | 12.5 | 14.1 | 14.2 | 16.1 | 17.1 | 17.4 | 18.1 | 19.1 | 20.1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Ribes triste* | | | | | | | | | | | 1 | | 1 | | 1 | | | |
| *Rosa acicularis* | | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| *Rubus chamaemorus* | | | | | | | | | | | | | | | | | | 1 |
| *Rubus idaeus* | | | | | 1 | | | 1 | 1 | 1 | 1 | | 1 | | 1 | | 1 | |
| *Rubus pedatus* | | | | | | | | 1 | | | | | | | | | | |
| *Rubus pubescens* | | 1 | 1 | 1 | | 1 | | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | | 1 | |
| *Rumex triangulivalvis* | 1 | | | | | | | | | | | | | | | | | |
| *Sagittaria cuneata* | | | | | | | | | | | | | | | | | | |
| *Sambucus racemosa* | | | | | | 1 | | 1 | | | | | | | | | | |
| *Sanicula marilandica* | | | | | | | | | | | | | | | | | | |
| *Schizachne purpurascens* | | | | | | | | | | | | | | | | | | |
| *Scirpus validus* | | | | | | | | | | | | | | | | | | |
| *Scutellaria galericulata* | | | 1 | 1 | | | | | 1 | | | | | | | | 1 | |
| *Shepherdia canadensis* | | | | | | | | | | | | | | | | | | |
| *Smilacina stellata* | | | | | | | | 1 | | | | | | | | | | |
| *Smilacina trifoliata* | | | | | | | | | | | | | | 1 | | | | |
| *Solidago canadensis* | | | | | 1 | | | | | 1 | | 1 | | 1 | | | | |
| *Sonchus arvensis* | | | | | | | | | | | | | | | | | | |
| *Sorbus scopulina* | | | | | | | | 1 | | | | | | | | | | |
| *Sparganium angustifolium* | | | | | | | | | | | | | | | | | | |
| *Sparganium eurycarpum* | | | | | | | | | | | | | | | | | | |
| *Stellaria calycantha* | | | | | | | | | | | | | | | | | | |
| *Stellaria longifolia* | | | | | | | 1 | | | | | | | | | | | |
| *Symphoricarpos albus* | | 1 | | | 1 | | | | | 1 | 1 | | 1 | | 1 | | | |
| *Taraxacum officinale* | | | | | 1 | | 1 | | | 1 | | | | | | | | |
| *Thalictrum venulosum* | | 1 | | | | 1 | | | | | | | | | | | | |
| *Trientalis borealis* | | 1 | | | | | | | | | | | | | | | | |
| *Trifolium hybridum* | | | | | | | 1 | | | | | | 1 | | | | | |
| *Typha latifolia* | | | | | | | | | | | | | | | | | | |
| *Urtica dioica* | | | | | | | | | | | | | | | | | | |
| *Vaccinium caespitosum* | | | 1 | 1 | | | | | | | | | | | | | | |
| *Vaccinium myrtilloides* | | | | | | | | | | | | | | | | | | |
| *Veronica americana* | | | | | | | | | | | | | | | | | 1 | |
| *Viburnum edule* | | | 1 | 1 | 1 | | | 1 | 1 | 1 | 1 | | 1 | | 1 | | 1 | |
| *Vicia americana* | | | | | 1 | | | | | 1 | 1 | | 1 | | 1 | | | |
| *Viola candensis* | | | | | | | | | | | | | | | | | | |
| *Viola renifolia* | | 1 | | | | 1 | 1 | | | | 1 | | 1 | | 1 | | | |

Appendix 2 (continued)

| | 21.1 | 22.1 | 23.1 | 23.2 | 24.1 | 25.1 | 25.2 | 26.1 | 26.2 | 27.1 | 28.1 | 29.1 | 30.1 | 30.2 | 31.1 | 31.2 | 32.1 | 33.1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Achillea millefolium* | | | | 1 | 1 | | 1 | 1 | | 1 | 1 | | 1 | 1 | 1 | | | |
| *Achillea sibrica* | | | | | | | 1 | 1 | | | | | | | | | | |
| *Actaea rubra* | | | | 1 | 1 | | 1 | 1 | | | | | 1 | | | | 1 | 1 |
| *Agropyron trachycaulum* | | | | | | | | | | | | | | | | | 1 | |
| *Agropyron trachycaulum unilaterale* | | | | | | | | | | | | | | | | | 1 | |
| *Agrostis scabra* | | | | | | 1 | | | | | | | | | | | | |
| *Amelanchier alnicola* | | | | | 1 | | | | | | 1 | | | | | | 1 | 1 |
| *Andromeda polifolia* | | | | | | | | | | | | | | | | 1 | | |
| *Apocynum androsaemifolium* | | | | | | | | | | | | | | | | | | |
| *Aralia nudicaulis* | | | | | | 1 | | | | | | | 1 | | | | 1 | |
| *Arctostaphylos uva-ursi* | | 1 | | | | | 1 | | | 1 | | | | | 1 | | | |
| *Arnica cordifolia* | | | | 1 | | | 1 | 1 | | | | | 1 | | | | 1 | |
| *Aster conspicuous* | | | | | | | | | | | 1 | | | | | | 1 | |
| *Aster ciliolatus* | 1 | | | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | | 1 | 1 | 1 | | 1 | 1 |
| *Aster puniceus* | | 1 | | | 1 | | 1 | 1 | | 1 | | | | | | | 1 | 1 |
| *Astragalus canadensis* | | | | | | | | | | | | | | | | | 1 | 1 |
| *Athyrium filix-feminia* | | | | | | | | | | | | | | | | | | |
| *Betula glandulosa* | 1 | | | | | | | | | | | | | | | | | |
| *Botrychium virginianum* | | | | | | | | | | | | | | | | | | |
| *Bromus ciliatus* | | | | | | | 1 | | | | | | | 1 | | | 1 | 1 |
| *Bromus inermis* | | | | | | | | | | | | | | | | | | 1 |
| *Calamagrostis canadensis* | | | | 1 | 1 | | 1 | 1 | | 1 | 1 | | 1 | 1 | | | 1 | 1 |
| *Calamagrostis inexpansa* | | | | | | | | | | | | | | | | 1 | | |
| *Callitriche verna* | | | | | | | | | | | | 1 | | | | | | |
| *Caltha palustris* | 1 | | | | | | | | | | | | | | 1 | | | |
| *Campanula rotundifolia* | | 1 | | | | 1 | 1 | 1 | | | | | | | | | | |
| *Carex aquatilis* | | | | | 1 | | | | | | | | | | | | | |
| *Carex atherodes* | 1 | 1 | | | | | | | | | | | | | | | | 1 |
| *Carex disperma* | | | | | | | | | | 1 | | | | | | | | |
| *Carex siccata* | | | | | | | | | | 1 | | | | | | | | |
| *Carex temuifolia* | | | 1 | | | | | | | | | | | | | 1 | | |
| *Castilleja miniata* | 1 | | | | | 1 | 1 | 1 | | | | | | | | | | |
| *Ceratophyllum demersum* | | | | | | | | | | | | 1 | | | | | | |
| *Chrysanthemem leucanthemum* | | | | 1 | | | | | | 1 | | | | | | | | |
| *Chrysosplenium tetrandrum* | | | | | | | | | | | | | | | | | | |
| *Cinna latifolia* | | | | | | | 1 | | | | | | | | | | | |

Appendix 2 (continued)

| | 21.1 | 22.1 | 23.1 | 23.2 | 24.1 | 25.1 | 25.2 | 26.1 | 26.2 | 27.1 | 28.1 | 29.1 | 30.1 | 30.2 | 31.1 | 31.2 | 32.1 | 33.1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Cornus canadensis* | | 1 | | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | | 1 | 1 |
| *Cornus stolonifera* | | | | | | | | | | | | | 1 | | | | | |
| *Cypripedium passerinum* | | | | | | | | | | | | | | 1 | | | | |
| *Delphinium glaucum* | | | | | | | | | | | | | | | | | | 1 |
| *Deschampsia caespitosa* | | | | | | | | | | | | | | | | | | |
| *Dryopteris carthusiana* | | | | | | | | | | 1 | | | | | | | | |
| *Elymus glaucus* | | | | | | | 1 | | | | | | | 1 | 1 | | 1 | 1 |
| *Elymus innovatus* | | | | | | | 1 | 1 | | | | | | | | | 1 | |
| *Epilobium angustifolium* | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | | 1 | | | 1 | 1 | 1 | | 1 | 1 |
| *Epilobium ciliatum* | | | | | | | | | | | | | | | | | 1 | |
| *Equisetum arvense* | 1 | 1 | 1 | | | 1 | 1 | 1 | | | 1 | | 1 | 1 | 1 | | 1 | |
| *Equisetum scirpoides* | | | | | | | | | | | | | | 1 | | | | |
| *Equisetum sylvaticum* | 1 | 1 | | 1 | | 1 | 1 | 1 | | 1 | 1 | | | | 1 | | | 1 |
| *Fragaria vesca* | | | | | | | | | | | | | | | | | | |
| *Fragaria virginiana* | 1 | 1 | | 1 | | 1 | 1 | 1 | | 1 | | | 1 | 1 | 1 | | 1 | 1 |
| *Galium boreale* | | | | 1 | 1 | | 1 | 1 | | | 1 | | 1 | 1 | 1 | | 1 | 1 |
| *Galium trifidum* | | | | | | | | | | 1 | | | 1 | | | | 1 | |
| *Galium trifolium* | | | | 1 | | | | | | | | | 1 | | | | | |
| *Geocaulon lividum* | | 1 | | | | | | | | | | | | | | | | |
| *Geum aleppicum* | | | | | | | | | | 1 | | | | | | | | |
| *Geum macrophyllum* | | | | 1 | | | | | | | | | | | | | | |
| *Gymnocarpium dryopteris* | | | | 1 | | | | | | | | | | | | | | |
| *Habenaria viridis* | | | | | | | | | | | | | | 1 | | | | |
| *Heracleum lanatum* | | | | | | | | | | | 1 | | | | | | 1 | 1 |
| *Hieracium umbellatum* | | | | | 1 | 1 | 1 | | | 1 | | | 1 | | | | 1 | |
| *Hierochloe odorata* | | | | | | | 1 | 1 | | 1 | | | | | | | | |
| *Hordeum jubatum* | | | | | | | | | | | | | | | | | 1 | |
| *Impatiens capensis* | | | | | | | | | | | | | | | | | | |
| *Juncus balticus* | | 1 | | | | | | | | | | | | | | | | |
| *Juncus nodosus* | | | | | | | | | | 1 | | | | 1 | | | | |
| *Juncus tenuis* | | | | | | | | | | | 1 | | | | | | | 1 |
| *Kalmia microphylla* | 1 | | | | | | | | | | | | | 1 | | | | |
| *Lathyrus ochroleucus* | | 1 | | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | | 1 | | | | 1 | |
| *Ledum groenlandicum* | 1 | 1 | 1 | 1 | | 1 | | | | 1 | | | | 1 | 1 | | 1 | |
| *Lemna minor* | | | | | | | | | | | | 1 | | | | | | |
| *Linnaea borealis* | | 1 | | 1 | | 1 | 1 | 1 | 1 | | | | 1 | 1 | 1 | | 1 | 1 |
| *Lonicera dioca* | | | | 1 | 1 | | | | | | | | | | | | 1 | |

Appendix 2 (continued)

| | 21.1 | 22.1 | 23.1 | 23.2 | 24.1 | 25.1 | 25.2 | 26.1 | 26.2 | 27.1 | 28.1 | 29.1 | 30.1 | 30.2 | 31.1 | 31.2 | 32.1 | 33.1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Lonicera involucrata* | | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | | | | 1 | | 1 | | 1 | 1 |
| *Luzula parviflora* | | | | | | | 1 | 1 | | | | | | | | | | |
| *Lycopodium annotinum* | | | | 1 | | | | | | 1 | | | | | | | | |
| *Maianthemum canadense* | | | | 1 | | | 1 | 1 | | 1 | | | 1 | | 1 | | 1 | |
| *Matteuccia struthiopteris* | | | | | | | | | | | | | | | | | | |
| *Melilotus officinalis* | | | | | | | | | | | | | | | | | | |
| *Menyanthes trifoliata* | | | | | | | | | | | | | | | | | | |
| *Mertensia paniculata* | 1 | | | 1 | 1 | 1 | 1 | 1 | | | 1 | | 1 | 1 | | | 1 | 1 |
| *Mitella nuda* | | | | 1 | | | | | | | | | 1 | 1 | 1 | | 1 | 1 |
| *Moneses uniflora* | | | | | | | | | | | | | | | | | | |
| *Myriophyllum exalbescens* | | | | | | | | | | | | 1 | | | | | | |
| *Nuphar variegatum* | | | | | | | | | | | | 1 | | | | | | |
| *Oplopanax horridum* | | | | | | | | | | | | | | | | | | |
| *Orchis rotundifolia* | | | | | | | | | | | | | | | | | | |
| *Oxycoccus microcarpus* | 1 | | 1 | | | | | | | | | | | | | 1 | | |
| *Parnassia palustris* | | | | | | | | | | | | | | 1 | | | | |
| *Petasites palmatus* | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | | 1 | | | 1 | 1 | 1 | | 1 | 1 |
| *Petasites sagittatus* | 1 | | | | | | | | | | | | | | | | | |
| *Phleum pratense* | | | | | | | 1 | 1 | | 1 | 1 | | | | | | 1 | 1 |
| *Polygonum amphibium* | | | | | | | | | | | | 1 | | | | | | |
| *Polygonum lapathifolium* | | | | | | | | | | | | 1 | | | | | | |
| *Potamogeton natans* | | | | | | | | | | | | 1 | | | | | | |
| *Potamogeton gramineus* | | | | | | | | | | | | 1 | | | | | | |
| *Potamogeton richardsonii* | | | | | | | | | | | | 1 | | | | | | |
| *Potentilla arguta* | | | | | 1 | | | | | | | | | | | | | |
| *Potentilla gracilis* | | | | | 1 | | | | | | | | | | | | | |
| *Potentilla palustris* | 1 | | | | | | | | | | | | | | | 1 | | |
| *Pyrola asarifolia* | | | | 1 | | | 1 | 1 | | | 1 | | 1 | | 1 | | 1 | |
| *Pyrola secunda* | | | | 1 | | | | | | | | | 1 | | | | | |
| *Ranunculus acris* | | | | | | 1 | 1 | | | | | | | | | | | |
| *Ribes americanum* | | | | 1 | | | | | | | | | | | | | | |
| *Ribes lacustre* | | | | | | 1 | | | | | | | | 1 | | | | |
| *Ribes oxyacanthoides* | | | | 1 | 1 | 1 | | 1 | | | | | 1 | 1 | | | 1 | 1 |
| *Ribes triste* | | 1 | | 1 | | | 1 | 1 | | | | | 1 | | | | 1 | |
| *Rosa acicularis* | | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | | 1 | 1 |
| *Rubus chamaemorus* | | | 1 | | | 1 | | | | | | | | | | | | |
| *Rubus idaeus* | | | | | 1 | 1 | 1 | 1 | | 1 | | | 1 | | | | 1 | |

Appendix 2 (continued)

| | 21.1 | 22.1 | 23.1 | 23.2 | 24.1 | 25.1 | 25.2 | 26.1 | 26.2 | 27.1 | 28.1 | 29.1 | 30.1 | 30.2 | 31.1 | 31.2 | 32.1 | 33.1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Rubus pedatus* | | | | | | | | | | | | | | | | | | |
| *Rubus pubescens* | | | | 1 | 1 | | | 1 | | 1 | 1 | | 1 | 1 | 1 | | 1 | 1 |
| *Rumex triangulivalvis* | | | | | | | | | | | | | | | | 1 | | |
| *Sagittaria cuneata* | | | | | | | | | | | | 1 | | | | | | |
| *Sambucus racemosa* | | | | | | | | | | | | | | | | | | |
| *Sanicula marilandica* | | | | | | | | | | | | | | | | | 1 | |
| *Schizachne purpurascens* | | | | | | | 1 | 1 | | | | | | | 1 | | | |
| *Scirpus validus* | | | | | | | | | | | | 1 | | | | | | |
| *Scutellaria galericulata* | | | | | 1 | | 1 | 1 | | 1 | | | | | | | | |
| *Shepherdia canadensis* | | | | 1 | 1 | | 1 | 1 | | | | | | | | | 1 | |
| *Smilacina stellata* | | | | | | | | | | | | | | | | | | |
| *Smilacina trifoliata* | | | | | | | | | | | | | | 1 | | | | |
| *Solidago canadensis* | | 1 | | 1 | 1 | 1 | 1 | 1 | | | 1 | | | 1 | | | | |
| *Sonchus arvensis* | | | | | | | | | | | | | | | | | 1 | |
| *Sorbus scopulina* | | | | | | | | | | | | | | | | | | |
| *Sparganium angustifolium* | | | | | | | | | | | | 1 | | | | | | |
| *Sparganium eurycarpum* | | | | | | | | | | | | 1 | | | | | | |
| *Stellaria calycantha* | | | | | | | | | | | | | | | | | | |
| *Stellaria longifolia* | | | | | | | | | | | | | | | | | | |
| *Symphoricarpos albus* | | | | | 1 | | | | | | 1 | | 1 | | | | 1 | 1 |
| *Taraxacum officinale* | | | | | | | | | | | 1 | 1 | | | | | | |
| *Thalictrum venulosum* | | | | | 1 | | 1 | 1 | | | 1 | | | | | | 1 | 1 |
| *Trientalis borealis* | | | | | | | | | | | | | | | | | | 1 |
| *Trifolium hybridum* | | | | | 1 | 1 | 1 | 1 | | | 1 | | | | 1 | | 1 | |
| *Typha latifolia* | | | | | | | | | | | | 1 | | | | | | |
| *Urtica dioica* | | | | | | | | | | | | 1 | | | | | | |
| *Vaccinium caespitosum* | | 1 | | 1 | | | 1 | 1 | 1 | | | | | | 1 | | 1 | |
| *Vaccinium myrtilloides* | | 1 | | 1 | | | | | | | | | | | | | 1 | |
| *Veronica americana* | | | | | | | | | | | | | | | | | | |
| *Viburnum edule* | | | | 1 | 1 | | | | | 1 | 1 | | 1 | | | | 1 | |
| *Vicia americana* | | 1 | | 1 | 1 | 1 | 1 | 1 | | | | | 1 | | 1 | | 1 | |
| *Viola candensis* | | | | 1 | | | 1 | 1 | | | | | | | | | | |
| *Viola renifolia* | | | | 1 | | | 1 | | | | | | 1 | | | | 1 | 1 |

**Appendix 3.** Sites and regions of the Whitecourt study area that would benefit from further botanical exploration.

Under-represented regions of the study area:

- North-central regions accessible from roads starting at NW36-58-10-W5 and S-59-2-W5 and winding to the south.
- East shore of McLeod River north of 15th Baseline (marked in part by secondary highway 647).
- West shore of McLeod River south of 15th Baseline.
- Tangle of roads in south-east.
- Large tracts of public land without road access, mainly in the north-west and west part of the study area and just north-west of Chip Lake; SE Lobstick R. near where it leaves study area.
- Privately-held land (we allowed little time to obtain permission), largely in the east.

Under-represented / promising landscape features:

- Rock outcrops: Reported NW of Chip Lake (Twardy & Lindsay 1971), and may be present along the Pembina and McLeod Rivers. These habitats may support previously undetected species
- Stream beds: Flooded throughout the study area in July, making sampling impossible for remainder of summer season – *Ptychomitrium, Dicranella,* and other species associated with nutrient enrichment, in particular, may be found in these habitats. Return especially to site 44.1 for this reason.
- River (Paddle, Pembina, Lobstick, McLeod) banks and valleys: These habitats may interesting species because of their topographical variability and inaccessibility to development
- Grasslands: Cornish recommends eight be sampled, but eight grassland sites were not encountered in this study. Previously unencountered species may occupy these sites.
- Open water habitats: These habitats are not expected to support bryophytes, but they were under-represented in vascular plant sampling as well and may yield records for rare species.

Natural Areas recommended by Cornish (2001) that were not visited because of limited access to sites:

- Highway Natural Area
- Paddle River Natural Area

Appendix 3 (continued)

Sites on public land, with access, that were identified for investigation using air photos but which there was no time to investigate:

- Sites sampled for vascular plants that should be examined for non-vascular plants: 26.1, 26.2, 28.1, 31.1, 31.2, 32.1, 33.1
- NW4-54-13-W5 – variety of habitats, with disturbance, along stream
- Stream inlets and outflows, Chip Lake
- 18-54-10-W5 (approx vicinity): Western peninsula and islands of Chip Lake
- SE36-54-11-W5: Strings and associated public land in vicinity of Lobstick entrance to (NW) Chip Lake
- S24-54-14-W5: Carrot Creek, variety of human-disturbance and natural habitats
- 13-55-11-W5 & 18-55-10-W5: Topographical and habitat diversity NW of Chip Lake
- 13/14/15-55-12-W5: Patterned fen
- SE31-55-13-W5: McLeod River and valley
- NW7-56-10-W5 & S13-56-11-W5: Upland-wetland gradients
- 15$^{th}$ Baseline west of intersection with secondary highway 751 (from 34-56-11-W5 to 33-56-12-W5): habitat variety
- NE29-56-13-W5: McLeod River and valley
- NW16-57-13-W5 & NE21-57-13-W5 & S28-57-13-W5: McLeod River and valley
- S32-57-13-W5 & NE29/NW28-57-13-W5: Stream tributary to McLeod River
- S25&N24-58-11-W5, N10&S15-58-11-W5, W33-57-11-W5: interesting places on unexplored road
- E15-58-13-W5: McLeod River and valley
- SW5- & SE6-59-12-W5; 31-58-12-W5 and (closed) road starting there and running to the south-east: diversity of habitats and unique communities
- NW8- & NE7-59-12-W5: diversity of habitats and unique communities
- S24- & N13-59-12-W5: especially stream

Sites where potentially rare plants were observed, but which require further visits to confirm species identity:

- Site 3.3 (Beta Lake) – Immature *Dicranella* documented
- Site 6.1 (Inlet stream to McLeod River) – Immature *Dicranella* documented
- Site 6.5 (McLeod River) – Immature *Dicranella* documented
- Site 12.1 (Whitecourt Mountain Roadsides) – Immature *Dicranella* documented
- Site 16.3 (Blasted Beaver Dam) – Immature *Dicranella* and *Physcomitrium* documented
- Site 38.1 (Neckera pennata site) – Immature *Splachnum* documented
- Site 29.1 – submersed leaves of *Potamogeton natans* could not be observed due to high water

Appendix 3 (continued)

Locations that featured promising sites for which there was no time to sample:

- Habitats in Pembina River Provincial Park, particularly those associated with the river bed, were not observed in the study area and should be explored.
- Whitecourt Mountain was shown to support a relatively high number of rare non-vascular plant species in this study. Further attention to Whitecourt Mountain will probably reveal more rare plant populations, as will work in areas of raised elevation, naturally acidic soil or water chemistry, mature forests, and exposed rock if they can be located. These features probably contribute to the favourability of Whitecourt Mountain to the growth of rare plant species.

**Addendum.** Co-ordinates and descriptions of locales and sites visited for the lower foothills rare plant survey south-east of Whitecourt, Alberta.

(Each line corresponds to a site. The first column indicates whether the site was surveyed for rare vascular (V) or non-vascular (N) plants. Sites are numbered in the 'No.' column. The first part of each number corresponds to a locale, whereas the numbers following the decimal points correspond to each landscape feature (synonymous with 'site' in this study) that was sampled at that locale. Survey dates, UTM co-ordinates (NAD 83) and legal co-ordinates (range and township address) are provided. A brief habitat description for each site is followed by the landscape feature type (LF) into each site was classified (G=grassland/meadow, C=coniferous forest, D=deciduous forest, M=mixedwood forest, P=peatland/marsh, LS=stream beds and river and stream banks, LL=shores of ponds and lakes, A=anthropogenic habitats). Where the survey site was associated with a named landmark, this name is given in the 'Comments' column.)

| | Date | UTM N | UTM E | Legal | Habitat | LF | Comments | No. |
|---|---|---|---|---|---|---|---|---|
| VN | 6/25/01 | 5945749 | 592041 | NE 7-54-11-W5 | Willow meadow | G | Nojack area | 1.1 |
| VN | 6/25/01 | 5945749 | 592041 | NE 7-54-11-W5 | Conifer forest | C | Nojack area | 1.2 |
| VN | 6/25/01 | 5945749 | 592041 | NE 7-54-11-W5 | Black spruce bog | P | Nojack area | 1.3 |
| V | 6/25/01 | 5945749 | 592041 | NE 7-54-11-W5 | Stream side | LS | Nojack area | 1.4 |
| N | 6/25/01 | 5945749 | 592041 | NE 7-54-11-W5 | Roadside ditch | A | Nojack area | 1.5 |
| VN | 6/26/01 | 5954861 | 593534 | SW 9-55-11-W5 | Littoral zone - Beta Lake | LL | Beta Lake Campground | 2.1 |
| N | 6/26/01 | 5954861 | 593534 | SW 9-55-11-W5 | Mixedwood upland | M | Beta Lake Campground | 2.2 |
| VN | 6/26/01 | 5954793 | 593840 | SW 9-55-11-W5 | Mixedwood upland | M | Beta Lake Natural Area | 3.1 |
| VN | 6/26/01 | 5954793 | 593850 | SW 9-55-11-W5 | Sedge-land | G | Beta Lake Natural Area (south) | 3.2 |
| VN | 6/26/01 | 5954793 | 593850 | SW 9-55-11-W5 | Stream | LS | Beta Lake Natural Area (south) | 3.3 |
| VN | 6/26/01 | 5955162 | 593861 | SW 9-55-11-W5 | Willow wetland | P | Beta Lake Natural Area (south) | 3.4 |
| VN | 6/26/01 | 5956520 | 594531 | NW 9-55-11-W5 | Black spruce bog | P | Beta Lake Natural Area (north) | 4.1 |
| V | 8/17/01 | 5955821 | 594452 | NE 9-55-11-W5 | Pine/aspen upland | M | Beta Lake Natural Area (north) | 4.2 |
| V | 8/17/01 | 5955821 | 594452 | NE 9-55-11-W5 | Aspen forest | D | Beta Lake Natural Area (north) | 4.3 |
| VN | 6/26/01 | 5955737 | 585061 | NE 9-55-12-W5 | Unforested peatland | P | Sunset Lake (Hattonford Dump) | 5.1 |
| VN | 6/27/01 | 5987476 | 576000 | NE 22-58-13-W5 | Stream banks, gravel bars | LS | McLeod River | 6.1 |
| VN | 6/27/01<br>9/15/01 | 5987476 | 576000 | NE 22-58-13-W5 | Old-growth floodplain mixedwood | M | McLeod River | 6.2 |
| VN | 6/27/01 | 5987476 | 576000 | NE 22-58-13-W5 | Oxbow – overgrown | P | McLeod River | 6.3 |
| VN | 6/27/01 | 5987476 | 576000 | NE 22-58-13-W5 | Aspen forest – upslope | D | McLeod River | 6.4 |
| N | 6/27/01 | 5987476 | 576000 | NE 22-58-13-W5 | River banks | LS | McLeod River | 6.5 |
| VN | 6/27/01 | 5997271 | 578393 | NW 19-59-12-W5 | Black spruce bog | P | Whitecourt area | 7.1 |
| VN | 6/27/01 | 5998761 | 582914 | SE 28-59-12-W5 | Moist willow forest | D | Whitecourt area | 8.1 |
| VN | 6/27/01 | 5998800 | 582824 | SE 28-59-12-W5 | Black spruce/larch bog | P | Whitecourt area | 8.2 |
| VN | 6/27/01 | 5998425 | 583200 | SE 28-59-12-W5 | High on slumping river bank mud | LS | McLeod River near Whitecourt | 8.3 |

Addendum (Continued)

| | Date | UTM N | UTM E | Legal | Habitat | LF | Comments | No. |
|---|---|---|---|---|---|---|---|---|
| VN | 6/27/01 | 5997104 | 588199 | SE 24-59-12-W5 | Pine forest | C | Whitecourt Forest Interpretive Centre | 9.1 |
| VN | 6/27/01 | 5997101 | 588059 | SE 24-59-12-W5 | Pine/alder forest slope to creek | M | Whitecourt Forest Interpretive Centre | 9.2 |
| VN | 6/27/01 | 5990948 | 576519 | NW 35-58-13-W5 | Aspen/Birch/Willow forest | D | McLeod River | 10.1 |
| N | 6/27/01 | 5990948 | 576519 | NW 35-58-13-W5 | Shore of oxbow lake | LL | McLeod River | 10.2 |
| VN | 6/28/01 | 5988910 | 584132 | NE 21-58-12-W5 | Birch forest | D | Whitecourt Mountain N.A. | 11.1 |
| N | 6/28/01 | 5988910 | 584132 | NE 21-58-12-W5 | Wet meadow in man-made clearing | A | Whitecourt Mountain N.A. | 11.2 |
| VN | 6/28/01 | 5988193 | 584113 | NE 21-58-12-W5 | Moist willow forest | D | Whitecourt Mountain N.A. | 11.3 |
| VN | 6/28/01 | 5987915 | 584289 | NE 21-58-12-W5 | Pine forest | C | Whitecourt Mountain N.A. | 11.4 |
| N | 8/02/01 | 5988591 | 583897 | SE 28-58-12-W5 | Sandy undercut road side | A | Whitecourt Mountain N.A. | 12.1 |
| VN | 6/28/01 | 5988996 | 583801 | SE 28-58-12-W5 | High, steep sand bank | A | Whitecourt Mountain N.A. | 12.2 |
| N | 8/02/01 | 5988996 | 583801 | SE 28-58-12-W5 | Stream – road edge | LS | Whitecourt Mountain N.A. | 12.3 |
| VN | 6/28/01 | 5989040 | 583397 | SW 28-58-12-W5 | Tiny stream across cut-line and through aspen/willow stand | LS | Whitecourt Mountain | 12.4 |
| VN | 6/28/01 | 5989040 | 583397 | SW 28-58-12-W5 | Moist aspen forest | D | Whitecourt Mountain | 12.5 |
| N | 6/28/01 | 5989773 | 584132 | SW 34-58-12-W5 | Pond shore | LL | Whitecourt Mountain | 13.1 |
| VN | 6/28/01 | 5994197 | 589741 | NE 7-59-11-W5 | Mixedwood upland | M | Whitecourt Natural Area | 14.1 |
| VN | 6/28/01 | 5994197 | 589741 | NE 7-59-11-W5 | Black spruce bog | P | Whitecourt Natural Area | 14.2 |
| N | 8/02/01 | 5993484 | 589893 | SW 8-59-11-W5 | Mature mixedwood | M | Whitecourt Natural Area | 15.1 |
| N | 8/02/01 | 5993484 | 589893 | SW 8-59-11-W5 | Dry coniferous forest | C | Whitecourt Natural Area | 15.2 |
| N | 8/02/01 | 5993484 | 589893 | SW 8-59-11-W5 | Eroding stream bank | LS | Whitecourt Natural Area | 15.3 |
| VN | 6/29/01 | 5985324 | 604946 | NE 10-58-10-W5 | Mixedwood forest | M | | 16.1 |
| N | 6/29/01 | 5985324 | 604946 | NE 10-58-10-W5 | Pond shore | LL | | 16.2 |
| N | 6/29/01 | 5985324 | 604946 | NE 10-58-10-W5 | Exposed mud | A | | 16.3 |
| VN | 6/29/01 | 5979268 | 608961 | SE 25-57-10-W5 | Lakeside treeless peatland | P | | 17.1 |
| VN | 6/29/01 | 5979268 | 608961 | SE 25-57-10-W5 | Black spruce bog | P | | 17.2 |
| N | 6/29/01 | 5979268 | 608961 | SE 25-57-10-W5 | Betula-dominated peatland | P | | 17.3 |
| VN | 6/29/01 | 5979415 | 608660 | SE 25-57-10-W5 | Mixedwood upland | M | | 17.4 |
| N | 6/29/01 | 5979440 | 608643 | SE 25-57-10-W5 | Willow-dominated wetland | P | | 17.5 |
| VN | 6/29/01 | 5978800 | 614250 | NW 22-57-9-W5 | Pine/black spruce | P | Balm Natural Area | 18.1 |
| VN | 6/29/01 | 5941900 | 603650 | NW 33-53-10-W5 | Moist conifer forest | C | Chip Lake shore | 19.1 |

Addendum (Continued)

| | Date | UTM N | UTM E | Legal | Habitat | LF | Comments | No. |
|---|---|---|---|---|---|---|---|---|
| V | 7/27/01 | 5947100 | 567300 | NE 15-54-14-W5 | Black spruce bog | P | NE of Peers - previous Drosera EO | 20.1 |
| V | 7/27/01 | 5956500 | 574000 | NW 16-55-13-W5 | Black spruce/larch bog | P | very wet | 21.1 |
| V | 7/27/01 | 5955100 | 575750 | NW 10-55-13-W5 | Pine upland | C | Sandy | 22.1 |
| VN | 7/27/01<br>8/01/01 | 5942250 | 580000 | NE 35-53-13-W5 | Black spruce bog | P | Niton transfer station | 23.1 |
| V | 7/27/01 | 5942250 | 580000 | NE 35-53-13-W5 | Mixedwood forest | M | Niton transfer station | 23.2 |
| V | 8/13/01 | 5941500 | 623000 | NE 29-53-8-W5 | Riparian mixedwood | M | North bank of Lobstick River | 24.1 |
| V | 8/13/01 | 5959000 | 614500 | NW 22-55-9-W5 | Young aspen/willow forest | D | Alpha Lake | 25.1 |
| V | 8/13/01 | 5959000 | 614500 | NW 22-55-9-W5 | Aspen/Pine forest | M | Alpha Lake | 25.2 |
| N | 8/02/01 | 5959000 | 614500 | NW 22-55-9-W5 | Peatland | P | Alpha Lake | 25.3 |
| V | 8/13/01 | 5946600 | 619300 | NW 12-54-9-W5 | Aspen/Pine forest | M | Near Lobstick River | 26.1 |
| V | 8/13/01 | 5946000 | 619000 | NW 12-54-9-W5 | Pine upland | C | Near Lobstick River | 26.2 |
| NV | 8/13/01<br>9/14/01 | 5940850 | 592450 | NE 30-53-11-W5 | Pine forest | C | Nojack Recreation Area | 27.1 |
| V | 8/13/01 | 5940200 | 573900 | NW 29-53-13-W5 | Riparian mixedwood | M | Carrot Creek | 28.1 |
| V | 8/15/01 | 5945800 | 612800 | NE 8-54-9-W5 | Littoral zone - Chip Lake | LL | Chip Lake - canoed from NW 13-54-10-W5 to NE 8-54-9-W5 | 29.1 |
| N | 9/14/01 | 5945800 | 612800 | NE 8-54-9-W5 | Willow thickets | D | NE corner of Chip Lake | 29.2 |
| N | 9/14/01 | 5945800 | 612800 | NE 8-54-9-W5 | Aspen forests | D | | 29.3 |
| V | 8/16/01 | 5949750 | 599150 | SW 25-54-11-W5 | Mixedwood forest | M | Just west of Chip Lake | 30.1 |
| V | 8/16/01 | 5949750 | 599150 | SW 25-54-11-W5 | Black spruce bog | P | Just west of Chip Lake | 30.2 |
| V | 8/16/01 | 5949500 | 590800 | SE 25-54-12-W5 | Pine/aspen upland | M | | 31.1 |
| V | 8/16/01 | 5949500 | 590800 | SE 25-54-12-W5 | Larch bog | P | | 31.2 |
| V | 8/17/01 | 5957000 | 598000 | NE 14-55-11-W5 | Mixedwood forest | M | | 32.1 |
| V | 8/17/01 | 5959461 | 592085 | SE 29-55-11-W5 | Riparian mixedwood | M | | 33.1 |
| N | 8/01/01 | 5961235 | 572232 | SW 32-55-13-W5 | Steeply-sloping mixedwood | M | McLeod River | 34.1 |
| N | 8/01/01 | 5961235 | 572232 | SW 32-55-13-W5 | Exposed soil | LS | McLeod River | 34.2 |
| N | 8/01/01 | 5961235 | 572232 | SW 32-55-13-W5 | River bank | M | McLeod River | 34.3 |
| N | 8/01/01 | 5964933 | 573439 | SE 17-56-13-W5 | Black spruce bog | P | | 35.1 |
| N | 8/01/01 | 5964933 | 573439 | SE 17-56-13-W5 | Dry pine upland islands in bog | C | | 35.2 |
| N | 8/01/01 | 5964831 | 573587 | NE 21-56-13-W5 | Tamarack fen north of previous | P | | 36.1 |
| N | 8/01/01 | 5964831 | 573587 | NE 21-56-13-W5 | Dry upland pine | C | | 36.2 |

Addendum (Continued)

| | Date | UTM N | UTM E | Legal | Habitat | LF | Comments | No. |
|---|---|---|---|---|---|---|---|---|
| N | 8/01/01 | 5969639 | 575408 | SW 27-56-13-W5 | Steeply-sloping, slumping sand | LS | McLeod River | 37.1 |
| N | 8/01/01 | 5969689 | 583175 | SW 28-56-12-W5 | Mature aspen over spruce, managed woodlot | M | | 38.1 |
| N | 8/01/01 | 5960398 | 581654 | NW 29-55-12-W5 | Burnt black spruce bog | P | | 39.1 |
| N | 8/02/01 | 5988553 | 587737 | SW 25-58-12-W5 | Grazed aspen | D | | 40.1 |
| N | 8/02/01 | 5955945 | 612862 | SE 9-55-9-W5 | Grazed (in part) young aspen | D | | 41.1 |
| N | 8/02/01 | 5957455 | 609588 | NW18-55-9-W5 | Willow peatland | P | | 42.1 |
| N | 8/02/01 | 5957455 | 609588 | NW18-55-9-W5 | Stream | LS | | 42.2 |
| N | 8/02/01 | 5957455 | 609588 | NW 18-55-9-W5 | Tamarack peatland | P | | 42.3 |
| N | 3/09/01<br>9/14/01 | 5941246 | 633106 | NE 30-53-7-W5 | Roadsides and historical structures | A | Pembina River Provincial Pk | 43.1 |
| N | 9/14/01 | 5942415 | 579610 | NW 26-53-14-W5 | Stream | LS | Near Jct Hwy 16 & 32 | 44.1 |
| N | 9/15/01 | 5967146 | 586303 | NE 15-56-12-W5 | Stream | LS | | 45.1 |
| N | 9/15/01 | 5967146 | 586303 | NE 15-56-12-W5 | Mixedwood | M | | 45.2 |
| N | 9/15/01 | 5967146 | 586303 | NE 15-56-12-W5 | Aspen | D | | 45.3 |
| N | 9/15/01 | 5967146 | 586303 | NE 15-56-12-W5 | Disturbed edges | A | | 45.4 |
| N | 9/16/01 | 5973858 | 604429 | NW 3-57-10-W5 | Aspen Forest | D | Near dump | 46.1 |
| N | 9/16/01 | 5987960 | 604051 | NW 22-58-10-W5 | Aspen Forest | D | | 47.1 |

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